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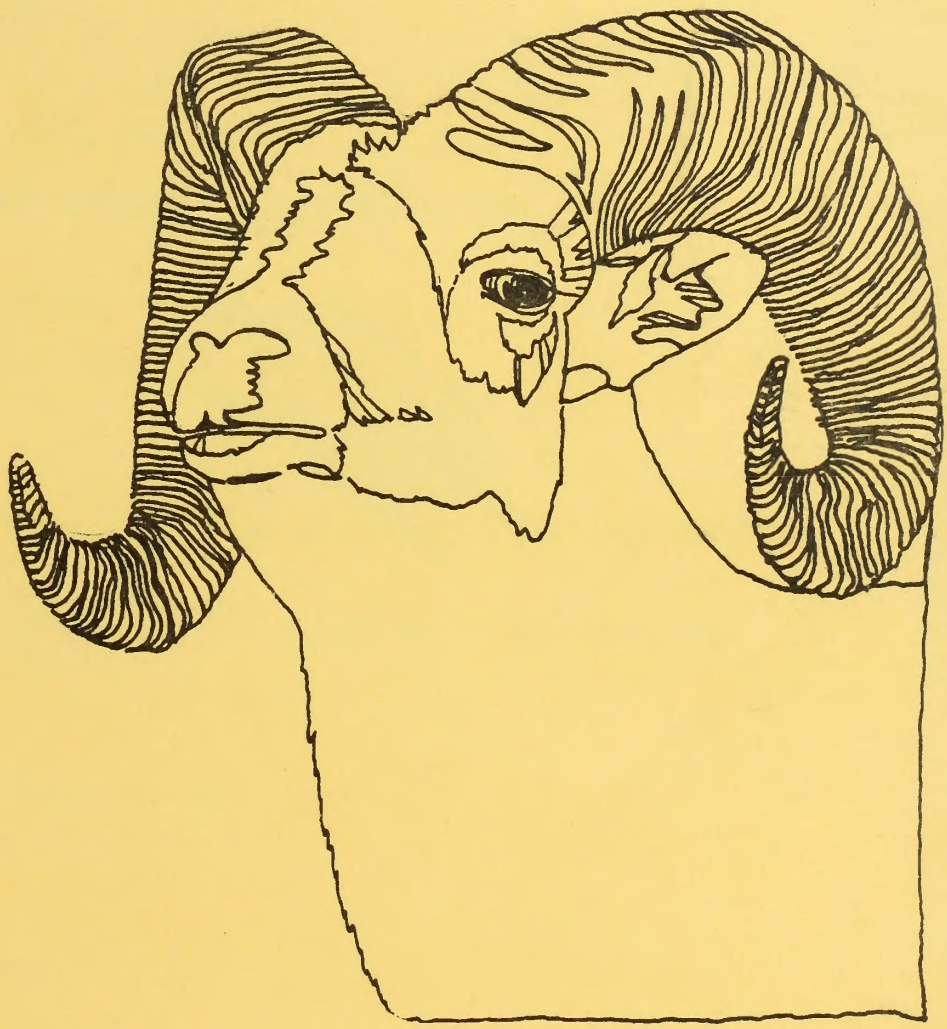
ECOLOGY OF THE DESERT BIGHORN SHEEP IN SOUTHEASTERN UTAH

SECOND YEAR FINAL REPORT



NOVEMBER 1982

By

Michael M. King

Gar W. Workman

BUREAU OF LAND MANAGEMENT UTAH

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SECOND YEAR FINAL REPORT

THE ECOLOGY OF THE DESERT BIGHORN SHEEP IN SOUTHEASTERN UTAH

CONTRACT NUMBER

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PROJECT ASSOCIATES:

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NOVEMBER 30, 1982

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ABSTRACT

Phase Two of the study of the ecology of desert bighorn sheep on Bureau of Land Management lands in southeastern Utah began 1 December, 1981. In February 1982, 7 additional sheep (5 ewes, 2 rams) were collared to more comprehensively monitor various aspects of bighorn ecology. Desert bighorn rams were found to have larger home range areas than ewes and to show seasonal movements to breeding areas. Ewes showed some degree of seasonal movement to lambing areas. Analysis of forage utilization data indicated that bighorn are primarily browsers throughout the year; but that diets vary seasonally and annually. A few interactions between cattle and mining activities with bighorn sheep were observed. The possible impacts of these activities are discussed. Recreation activities, including boating, hiking, off-road vehicle touring, and hunting were monitored in the area. These activities and their impacts on sheep as well as other human disturbances are discussed. Sheep were relatively disease free, with the exception of a group of sheep in the Blue Notch Canyon area that were infected by some type of mouth disease. The circumstances surrounding this incident are described.

ACKNOWLEDGEMENTS

We would like to thank the Bureau of Land Management for the financial support of the project. Several BLM employees have contributed much to the success of the project. Special thanks to Joe Cresto, COAR, for his involvement in the project, to Rich McClure, San Juan Resource Area Biologist, for sharing his knowledge of the area and fecal analysis results, and to Bill McMahon and Jerry Fehringer for their assistance in making sure the project made the transition between phases smoothly.

The Utah Division of Wildlife Resources has also provided much assistance to the project. The vehicle and living quarters used by the researchers were provided by the UDWR. Jim Bates, Southeast Region Game Manager, and Derris Jones, Southeast Region Game Biologist, captured and collared the bighorn sheep; an often dangerous task. The UDWR also provided the airplane for fixed-wing telemetry flights.

Special thanks goes to Jack Conroy, helicopter pilot, for his expertise in getting us to where the sheep were.

Thanks also goes to Canyonlands National Park personnel, especially Tom Wylie and Sandra Halloway, for their cooperation in providing information regarding recreation activities in the area.

Carl Mahon unselfishly donated much of his time in orienting us with the area and the sheep. He also took us up the Colorado River in his boat to observe sheep in Cataract Canyon. His assistance is greatly appreciated.

Dr. Robert Hedelius, U.S. Department of Agriculture Veterinarian collected and analyzed blood samples collected from desert bighorn sheep.

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INTRODUCTION

Purpose

The desert bighorn sheep (Ovis canadensis nelsoni), native animals to the harsh canyon country of southeastern Utah, is one of the most sought after game animals in North America for consumptive as well as nonconsumptive purposes. As a component of arid and often times fragile desert ecosystems, it requires close management as our human population expands it's realm of use into bighorn sheep habitat for mineral exploration and extraction, livestock operations, recreation opportunities, etc. Expanded human use into bighorn habitat necessitates good research to determine ecological requirements of the bighorn so that critical components may be protected and conserved to insure that the desert bighorn sheep will always be a part of our desert ecosystems.

Desert bighorn sheep have been studied extensively by several researchers in Utah during the past 15 years. Wilson (1968) conducted the first study on desert bighorn sheep in Utah. His pioneering study was conducted primarily in the rugged canyons of San Juan county, Utah, particularly in the areas of Red and White Canyons. He concluded that the population was static as a result of several limiting factors including: 1) lack of available water, 2) competition with cattle and deer, 3) internal parasites, and 4) high lamb mortality. Wilson also believed that lambing grounds were traditional, with ewes using the same area for lambing year after year. Irvine (1969) in a follow-up study to Wilson's, concluded that in the Red Canyon area there was no migration of desert bighorn sheep but that seasonal movements due to the availability of water did occur. Contrary to Wilson, Irvine felt that

lambing grounds were not traditional and that the population was growing as a result of low lamb mortality. Differences seen by Wilson and Irvine may be attributable to low precipitation during Wilson's study compared to relatively high precipitation during Irvine's study.

Bates et al. (1975) conducted the first telemetry study on Utah's desert sheep in the same general areas as the previous studies as well as the Glen-Dark Canyon areas to the north. Radio-collared sheep were monitored via fixed-wing aircraft from 1972-1975 in an effort to learn more of the sheep's seasonal movement and distribution. They found that the rams occupied generally larger home ranges and higher elevations than the ewes.

Dean (1977) conducted the first study on the ecology of desert bighorn sheep in Canyonlands National Park, Utah. He was primarily concerned with the distribution and abundance of sheep within the park. He felt that human and livestock activities in the park were limiting bighorn distribution and recommended that livestock grazing be discontinued within park boundaries. He also found no migration of sheep but did observe seasonal movements by rams before and after the rut as they moved to and from areas of ewe concentration for breeding, similar to the patterns observed by Wilson (1968) and Irivne (1969).

Although these early studies provided much needed baseline data on sheep distribution and abundance, life history, and behavior. There remain many questions concerning the ecology of the desert bighorn sheep in Utah that remain unanswered. For example, there has never been an intensive follow-up study in the Red-White Canyon area since Irvine completed his work in 1969. Information on current status of sheep movements, abundance and distribution, and population trend is sketchy at best. Since that time, mining and recreation activities have fluctuated, while livestock uses have

have remained about the same. Mining exploration peaked during the late 1970's and has been declining since then. Recreational activity may have also declined during the same period. An intensive study with the aid of radio telemetry equipment and on-the-ground observations will allow assessment of current population trends and will help in providing data critical for development of the Bureau of Land Management's land use planning system, livestock grazing environmental statement, and for the best possible management of the desert bighorn sheep and it's habitat under the multiple use concept.

This is a report on the progress of the second phase of the long term study of the ecology of desert bighorn on BLM lands in southeastern Utah.

Objectives

The second year's study effort with reference to the ecology of desert bighorn on Bureau of Land Management lands in southeastern Utah includes the following objectives:

1. Continue literature search.
2. Capturing and fitting 6 to 10 desert bighorn sheep with radio transmitters.
3. Continue monitoring movements of bighorn both by aircraft and from the ground.
4. Gather physiological and disease information on captured sheep.
5. Continue to collect forage utilization data; including fecal samples.
6. Continue to collect data on the influences of recreational and mineral activities on bighorn sheep.
7. Continue to collect data on the influence of livestock grazing on bighorn sheep.

STUDY METHODS

Description of Study Area

Immediately south of Canyonlands National Park in southeastern Utah, the Bureau of Land Management administers extensive acreages of public land that provide suitable habitat for desert bighorn sheep. The bighorn sheep study area proper (Figure 1) is encompassed by the following boundries:

1. South Boundry - south rim of Red Canyon, Utah Highway 263.
2. East Boundry - Manti-Lasal National Forest.
3. North Boundry - Canyonlands National Park.
4. West Boundry - Glen Canyon National Recreational Area.

The study areas is composed some of the most rugged desert terrain found anywhere in the United States. Topography throughout the area is rough and broken. Canyons are very precipitous and not easily accessible to human use. Talus slopes and boulders are common throughout the canyons, with many slopes exceeding 100% grades.

The topography within the area varies considerably from region to region. The southern region of the study area (Red Canyon, White Canyon, Jacobs Chair) are characterized by high mesas and buttes of sandstone cliffs and talus slopes rising as much as 2000 feet from rough broken canyon bottoms. The northern region (Dark Canyon, Bowdie Canyon, Gypsum Canyon), though in rather close proximity, is constrastingly different in structure. Most striking about the northern region are the extremely deep, precipitous gorges falling as much as 1500 feet from the rim tops to the Colorado River and it's tributaries.

The soils of the area are usually shallow and not well developed.

Plant communities in the study area are typical of the Upper and Lower Sonoran Life Zones. Common communities found in the study area include: (1) Blackbrush - Galleta, on many of the canyon slopes and benches, (2) Shadscale - Galleta - Ephedra, common in many areas with south facing slopes and benches, (3) Pinyon - Juniper, found on mesa and rim tops throughout the study area, and (4) Salina Wild Rye - Galleta, on north or west facing slopes. Occassionally, junipers and other shrubs from the pinyon-juniper community are found on talus slopes and benches. Vegetation is usually sparse, but during years of good rainfall, plant production is greatly increased.

Temperatures range from 0° to 40°C throughout the year, and the average annual precipitation is generally less than 10 inches.

Procedures

Field work for the second phase of the study began February 1982 with the sheep captive operation. Full-time field work did not begin until June 1982 and continued through November 1982.

In order to more comprehensively study movements and habitat utilization of desert bighorn sheep in southeastern Utah, an additional 7 bighorn (5 mature ewes, a 3½ year old ram, a 5½ year old ram) were captured and fitted with radio-transmitters 7, 8 February 1982. This brought the total of collared sheep in the study area to 13 (Table 1). Sheep were located from a Hughes 500D jet helicopter and immobilized by shooting them with an injection of M99 (Etorphine). Telonics radio-transmitters were placed on the sheep and then sheep were released after being injected with M50-50 (Deprenorphine), the reversal drug to M99 (see photo section). Since that time monthly fixed-wing flights have been made and sheep have been located at least bi-weekly from the ground. All locations of collared sheep were recorded on U.S.G.S. 15-minute topographic maps. Home range sizes were determined by using radio-locations plotted on the map and estimating the total area with a dot grid.

Habitat utilization determined by recording slope aspect, topographic type and vegetation type each time radio-collared sheep and their associates were observed. The same procedure was followed to determine cattle habitat utilization.

Forage utilization by desert bighorn sheep was determined by recording frequencies of use of different plant species at various feeding sites. Use of a clum of grass, leaf or stem of forbs, or leader or leaf of shrubs constituted one instance of use (Lauer and Peek 1976). Instance of use was recorded for each sheep in the group being observed in rotation for as long as the sheep could be observed feeding. Forage was recorded by plant species when

possible or by forage class when species cound not be determined. At least 200 feeding instances were recorded during each month sheep were observed (July-December 1981, July-September 1982). The same procedure was followed when observing cattle feeding behavior except only 100 feedings instances were observed each month (November-December 1981).

Fecal samples were collected by BLM personnel for Winter 1979-80, Spring 1980, and Winter 1980-81 for bighron sheep and cattle. These samples were analyzed by Colorado State University. Fecal samples were collected by the researcher July-December 1981, and July-October 1982, but these samples have yet to be analyzed.

Cattle were moved into the study area in late October early November 1981. This allowed observations of cattle in sheep habitat through December 1982 while the researcher was in the field. Cattle locations were also made during fixed-wing telemetry flights from January 1982-June 1982. Cattle diets and sheep diets were compared to determine overlap of diet items.

Mining activity in the area was virtually non-existent during the 1982 field season. There was some assessment work as well as some drilling and exploration by a few mining companies in the area. Radio-collared sheep in close proximity to these activities were observed to determine if sheep were being impacted.

Influence of recreation on bighorn has also been difficult because of the relatively few observable encounters between recreationists and sheep. The influence has been evaluated in terms of sheep reaction with respect to the following variables each time the researcher observed an interaction between sheep and recreationists:

1. Group classification; ewes, ewes and lambs, rams, or rams, ewes and lambs together.

2. Group size; single animals, animals in groups of 2 to 7, and groups of animals greater than 7 individuals.

3. Distance to disturbance; close - 0 to 75 yds., medium - 75 to 300 yds., and far - greater than 300 yds.

4. Type of disturbance; hiker, vehicle, plane, and boat.

The response of sheep to the above variable was recorded as being: Light - little to no reaction to disturbance, Moderate - significant interruptions in normal behavior or casual movement away from area, and Extreme - hurried flight away from disturbance.

Fortuitous interactions between sheep and other human-imposed disturbances (eg. helicopter, fixed-wing aircraft, etc.) that were observed by the researcher were recorded in an attempt to determine sheep response.

Disease information was collected by the federal veterinarian who accompanied UDWR personnel during the transplant and capture operation that occurred February 1982. Blood samples were collected and analyzed to determine if sheep were infected with Brucellosis, Leptospirosis, Anaplasmosis, and Blue Tongue diseases. Sheep were also examined externally to determine if sheep were infected with chronic sinusitis, external parasites or other maladies. Successful bighorn sheep hunters were also questioned as to whether their rams had any physical abnormalities.

LITERATURE REVIEW

An intensive literature was completed during the first phase of the study (King and Workman 1981). History of desert bighorn in Utah, movements and distribution, influence of livestock, influence of mining activities, influence of recreation activities, and physiological and disease information were all reviewed and summarized. This literature summary deals with literature pertaining to those subjects that have been reviewed since the first phase of the project.

Movements and Habitat Utilization

Simmons (1961) studied daily and seasonal movements of bighorn sheep in Colorado in relationship to weather changes, topographic characteristics, vegetative characteristics, presence of other animal species and the availability of food, water, and minerals. Simmons concluded that bighorn had a mean daily cruising radius of 832 yards and that 2¼ miles in diameter. He also concluded that movements between feeding stations were limited because of the apparent good condition of the range. Sheep movements were influenced considerably by mineral licks as sheep were observed moving great distances to licks and remained near them for extended periods of time. He concluded that water had little effect on movements by Poudre River bighorn. Greatest daily movements occurred between spring and late summer. He also noted that bighorn reduced their daily cruising radius and movement rates during stormy days.

Barmore (1962) studied bighorn sheep in Dinasaur National Monument, Utah to determine abundance and distribution of sheep within the monument. He described a condition of seasonal movement, particularly by rams during the

breeding season. Rams, isolated from ewe groups during the remainder of the year, moved to join ewes on breeding grounds during the fall. He also suggested that water availability determined to some degree the extent of sheep movements. Abundant rainstorms created temporary water sources that possibly lead to a temporary dispersal of bighorn into areas that weren't otherwise used.

Welch (1968) studied desert bighorn sheep in the San Andreas National Wildlife Refuge, New Mexico. He concluded that bighorn sheep consistently use the same routes in traveling between major habitat units within the refuge. The movement routes or corridors were located in bluffy areas that connected areas of major use. Sheep used primarily two major habitat types; bluffs and open-browse sites. Sheep spent 62% of their time in bluffy areas thatwere particularly favorable sites for bedding.

Augsburger (1970) studied desert bighorn sheep in the San Andreas Mountains, New Mexico to compare their behavior with rocky mountain bighorn. He found two significant patterns of movements during the year. These movements were apparently caused by variation in the environment, and migration during the breeding season. Movements were observed by sheep from areas where water was scarce to areas where springs and seeps were common. During the breeding season rams moved great distances tojoin ewe groups for breeding. The rams moved in with ewes in July and remained during the breeding season until late October-early November.

Breyen (1971) evaluated habitat of desert bighorn in Nevada. He found that a majority of sheep use was in areas that contained many caves, cliffs, bluffs, ridges, etc. Grass, usually thought to be a

significant component of bighorn habitat had almost no correlation with habitat use by sheep. The distance to water was found to be inversely correlated to sheep use; more sheep use was observed the closer the distance to water.

Leslie (1978) studied the movements of desert bighorn in the River Mountians, Nevada. Patterns of movement and home ranges showed a high degree of variability; however, general trends were noted among sexes and various age classes. Ram home range sizes were generally larger than ewe home ranges. Ram home range sizes tended to increase with increasing age. He also concluded that bighorn sheep movements were dependent on season of year, distribution and abundance of water, forage conditions, topography, breeding conditions, and lambing activity.

Sandoval (1980) studied habitat utilization of desert bighorn sheep in the San Andreas Mountains, New Mexico. He found that the preferred habitat consisted of a series of broken cliffs, ledges, deep canyons, and rock out crops. These areas were designated as the cliff habitat type and accounted for 70% of sheep observations. Slope gradients between 20% and 60% were most heavily used and elevation use was greatest between 5500-6500 feet. Preferred habitats also had a 41% ground cover; shrubs 24%, grasses 14%, and forbs 3%. A close relationship was apparent between sheep distribution and the availability of water and escape terrain. Sandoval also found that the distribution of bighorn remained basically the same throughout the year. No appaprent dispersal corresponding to either the cool or moist periods of the annual cycle was discovered. Habitat use consisted primarily of gradual drifting within the cliff habitat type.

Bates (1982) studied desert bighorn habitat utilization in Canyonlands National Park, Utah. He found that desert bighorn habitat utilization was most strongly correlated with the cover value of the area, and

the distance to escape terrain, which was defined as steep rugged slopes and cliffs. Over 99% of all sightings were recorded within 0.38 miles of escape terrain. Cutler and talus slopes provided escape terrain and were used significantly by sheep. Those slopes were used for resting, escape terrain from human disturbance, and for feeding. Sheep used most rugged areas in the winter and least rugged area in the fall. Bates found that bighorn rams moved considerably throughout the year. He classified these as seasonal movements. Ewes in the area did not show seasonal movements, but both ewes and rams had variations in seasonal use of habitats.

Lawson and Johnson (1982) in a review article on mountain sheep describe general home range and movement patterns. They submit that home range size is generally smallest in winter when forage is scarcest; however, for desert bighorn sheep, summer home ranges may be smaller because of sheep dependence on limited water sources. They suggest that local distribution of sheep depends on habitat conditions, sex, and age of animals, and the season of the year. Seasonal movements may be affected by weather, availability of food or water, or reproduction urge.

Forage Utilization

Sandoval (1980) observed desert bighorn forage utilization in New Mexico from May 1975-April 1976. He found that desert sheep were primarily browsers throughout all four seasons. During Spring 1975, shrubs were selected 55.9%, forbs 30.3%, and grasses 10.3% by sheep. In Summer 1975, shrubs were selected 50.3%, forbs 28.7%, and grasses 15.8% by sheep. In Fall 1975, shurbs were slected 38.0%, forbs 47.6%, and grasses 9.2%. During Winter 1976, shrubs were selected 54.6%, forbs 33.4%, and grasses 6.6% by desert bighorn. The sharp increase in forb use during Fall 1975 corresponded with marked increases in precipitation. But, he also speculates that shrubs may have declined in palatability.

Sandoval noted some discrepencies between direct observation and fecal analyses methods for determining food habits. Shrubs were over-represented while grasses and forbs were under represented in direct observation sampling. In fecal analysis several plant species showed up in the diet not picked up by the observation method; however, some fleshy plants did not show up in the fecal analysis that did in direct observation sampling. This was attributed to more complete digestion of those fleshy plants. He concluded both methods should be used together for accurate results.

Bates (1982) studied food habits of desert bighorn in Canyonlands National Park Utah. He used a direct observation method to evaluate diet selection by the sheep. The annual diet consisted of 43.2% shrubs, 38.4% grasses, and 18.4% forbs. Shrubs were used less than there availability, and forbs greater than their availability in feeding areas. Galleta grass, Hilaria jamesii, and blackbrush, Coleogyne ramosissima, were the major

components of sheep diets. Bighorn sheep in the park showed a high degree seasonal diet variation. Use of shrubs was highest in winter (48.6%) and summer (46.3%) and lowest in spring (37.2%). Use of grasses was highest in the fall (43.7%), and forbs were used most during the spring (20.9%), and least in the fall (15.7%).

Bates' study is being followed by a study to determine nutritional value of plants selected by bighorn on a seasonal basis (Hull 1982).

Lawson and Johnson (1982) report that because desert bighorn occupy dry climates, their diets are dominated by browse plant species. Grass species are eaten throughout the year and is an important food reserve and at times is the major diet item depending on abundance, succulence, and nutritional quality.

Influence of Livestock

The effect of domestic livestock grazing on bighorn sheep range is very controversial and depends on the proximity and population size of the competing species. The forage resource and spatial overlap of potential competitors are usually considered as the major areas where competition may occur; however, social intolerance of domestic livestock by sheep is often overlooked (Lawson and Johnson 1982). Domestic livestock have been reported to have little negative effect if they do not graze and deplete forage on critical ranges (McCann 1956, Hudson et al. 1976). However, extensive use by livestock of public lands persists and is probably one of the major reasons sheep numbers have declined (Stelfox 1971).

Domestic sheep eat the same forage as wild sheep when on the same range. However, there is little spatial overlap of the species, except where bighorns move through domestic sheep range (Buechner 1960).

Competion between bighorn sheep and cattle has been reported to be a serious problem in British Columbia (Lawson and Johnson 1982) and in Idaho (Morgan 1973). Hudson et al. (1976), found that mountain sheep distributions were only weakly influenced by cattle. Halloran (1949) found that cattle in Arizona often deprived desert bighorn of range near critical water supplies in certain areas.

Bates (1982) presented circumstantial evidence that suggested domestic livestock have limited bighorn distribution in Canyonlands National Park. Dean (1977) and Follows (1969) noted that in the 1960's and 1970's desert bighorn sheep, particularly ewes, were not observed very often in areas used by livestock. In areas where sheep and cattle ranges overlapped, they occupied different portions of the canyons. Cattle used canyon

bottoms, while sheep used benches and rugged talus slopes. Since cattle were removed from a majority of areas in the park, sheep distribution has increased and sheep have moved into areas where they have not been previously observed.

Influence of Human Disturbance

Purdy and Shaw (1981) conducted an analysis of recreational use patterns in desert bighorn habitat in the Pusch Ridge Wilderness, Arizona. They suggest to better understand human bighorn interactions that 1) human use in bighorn habitats should be monitored, 2) backcountry hikers be provided with information about bighorn so they understand sheep habits and needs, 3) deter back country travel with dogs, cross-country travel, and camping within ¼ mile of wildlife water sources, and 4) provide no improvements in trail facilities in bighorn habitats.

Deforge (1981) suggests that desert bighron sheep are susceptible to stresses imposed by human disturbance. Continued exposure to these stressful conditions may result in weakened tissues, increased susceptibility to diseases, lowered reproductive rate, increased heart rates, major die-offs, etc. He also states that often times human disturbance of sheep can cause heart-rates to increase without any external appearance of stress.

Bates (1982) observed that human disturbances to bighorn sheep in Canyonlands National Park caused bighorn to flee to rugged slopes. The reaction of desert bighorn sheep to disturbance varied considerably from case to case, but appeared to be affected by habitat type the animal was in, distance to escape terrain, and type of disturbance. He reports that 41% of groups of desert bighorn sheep observed to come on contact with a human disturbance, moved to a different habitat type.

Disease Information

Several viral agents have been associated with bighorn sheep. Diseases caused by 3 of these agents all have similar symptoms and are very difficult if not impossible to diagnose based on external observation (Hedelius 1982, personal communication). Contageous ecthyma (sore mouth), blue tongue, and vesicular stomatitis all have similar symptoms. The 3 diseases are characterized by lesions and blisters or pustules on lips, face, ears, feet, eyes, and tongue. Sheep are often lethargic and sometimes lame due to swelling of coronary band above hooves. (Blood and Henderson 1968).

Contageous ecthyma usually runs a benign course and uncomplicated cases heal in about a month. Secondary infections, however, often result in death (Lawson and Johnson 1982). Contageous ecthyma can be very debilitating and may result in stunted growth. It is common in mountain sheep around salting areas where sheep often concentrate (Blood 1971, Samuel et. al. 1975). Sore mouth has been responsible for deaths of bighorn in California (Deforge et al. 1981).

Blue tongue, malignant catarrhal fever, is transmitted by a culiocoides gnat, hence is most troublesome in the wet season or around watering areas in the dry season. Desert bighorn have died of blue tongue disease under penned conditions in Texas and New Mexico (Allen 1980, Scott 1980). However, clinical cases in the wild are rare.

Vesicular stomatitis has not been reported in bighorn sheep. However, during 1982 an outbreak of vesicular stomatitis spread across the western United States in epidemic proportions in domestic livestock populations. Bighorn sheep were likely exposed to this viral agent during its spread

(Hedelius 1982, personal communication). The disease closely resembles hoof and mouth disease that is so devastating to domestic livestock. As with the other mouth diseases described, blisters form and swelling occurs in the mouth region of the animal. Affected aminals may refuse to eat, or even drink in some instances. There is no effective treatment for the disease, but can be diagnosed with blood tests (Blood and Henderson 1958).

Encephalitis, an arbovirus, also occurs in sheep. Little is known of its relationship to sheep, but antibodies were detected in 8 of 65 bighorns (12%) from Wyoming, Montana, and New Mexico (Trainer and Hansen 1969).

Parks et al. (1972) isolated PI-3 virus from bighorn with an acute respiratory illness. Of 30 bighorns from Wyoming tested, almost all were found to have been exposed to PI-3.

Results

Movements

Ram #148.065 (R65), now 3½ years old, was captured on the north side of Jacobs Chair Mesa February, 1981. Since that time, he has been located 29 times including fixed-wing telemetry flights as well as ground locations (Figure 2). Approximate home range size of R65 based on these locations was estimated to be 12.0 square miles. During this period, R65 was found primarily on Meonkopi and Chinle talus slopes (55.2% and 20.7% respectively). in the Blackbrush-Galleta vegetation type (51.7%), and was observed to use a majority of available slope aspects (Table 2). R65 spent the period from February 1981 to October 1981 in the vicinity of Jacobs Chair Mesa in close association with 3 mature ewes and their 3 lambs. With the onset of the rut in October, R65 left the ewe group and moved to the finger-like mesas approximately 3-4 airline miles west of Jacobs Chair Mesa. R65 remained in that area until March 1982, during which period he was observed consistently with a band of 8 ewes and lambs as well as 4 or 5 other rams of various ages.

Information on movements of R65 after March 1982 is lacking because of radio transmitter failure. A radio signal was last received from R65 25 March 1982 and R65 was not located again until October 1982. On 18 October 1982, R65 was visually located with a collared ewe, E200, in the same general vicinity of where he had been observed months earlier. This sighting of R65 confirmed radio failure.

It is unfortunate that the R65 radio malfunctioned because now we can only speculate whether or not he left the area and returned or remained in the area from March until October.

Ram #148.075 (R75), now 3½ years old, was captured in Rainbow Canyon

February 1981. Since that time, he has been located 31 times including fixed-wing telemetry flights and ground locations (Figure 3). Approximate home range size of R75 based on these locations was estimated to be 25.0 square miles. During this period, R75 was found primarily on Chinle talus slopes and benches (74.2%), in the Shadscale-Galleta-Ephedra vegetation type (74.2%), and on southeast and northwest facing slopes (35.5% and 29.0% respectively, Table 2.). R75 spent the period from February 1981 to January 1982 in the general vicinity of Mahon to January 1982 in the general vicinity of Mahon and Wilson Canyons with various ewe groups.

Unlike R65, R75 did not leave his summer range during the rut in 1981-82 but remained in Mahon and Wilson Canyons through January 1982. In February 1982, after the rut, R75 moved approximatedly 6 airline miles northeast of Wilson Canyon to Copper Point. R75 remained in this general area until May 1982, R75 had moved on top of the Windgate Mesa and by early July was located back in Wilson Canyon where he had spent the previous summer.

R75 remained in Wilson Canyon through July, but moved back up on top of the Windgate Mesa in August where he remained until the breeding season began in early October 1982. On 4 October 1982, R75 was observed in Blue Notch Canyon where he remained through October 1982. On 19 November, R75 was sighted on top of the Windgate Mesa above Wilson Canyon. The next day, 20 November R75 was located in Wilson Canyon during a helicopter census of the area.

Ram #148.135 (R135), now 2½ years old was captured in Rainbow Canyon, February, 1981. Since that time, he has been located 27 times including fixed-wing telemetry flights and ground locations (Figure 4). Approximate home range size based on these locations was estimated to be 41.0 square miles. During this period, R135 was found primarily on Chinle talus slopes and

benches (81.5%), in the Shadscale-Galleta-Ephedra and Salina Wild Rye-Galleta vegetation types (59.3%) and 22.2% respectively), an on virtually all slope aspects (Table 2). R135 spent the period from his capture in February 1981 to January 1982 in the Blue Notch Canyon-Hidden Valley area. During this time he was observed on several occassions with collared ewe E145 and her associates, particulary during the rut. When not with E145, R135 was observed with other young rams. As the rut declined in January 1982, R135 left E145 and moved south into Wilson Canyon in February 1982 where he was observed with E115 and R75. By March 1982, R135 had moved into Blue Canyon, approximately 10 airline miles southeast of Wilson Canyon where he was observed with 7 mature rams. This suggests that as larger rams left ewe groups at the close of the rut, R135 left with these larger sheep and accompanied them to new areas.

R135 remained in the Blue Canyon vicinity until August 1982 after which time no radio signals were received. No further sightings of R135 were made until 20 November, 1982 when he was sighted during a helicopter census; once again in Blue Notch Canyon with E145 and associates. This sighting confirmed radio failure.

Ram #148.155 (R155), now 3½ years old, was captured near the mouth of Dark Canyon, February, 1981. Since that time, R155 has been located 15 times including fixed-wing telemetry flights and ground locations (Figure 5). Approximate home range size based on these locations was estimated to be 14.0 square miles. During this period, R155 was always found on the steep, rugged talus slopes and benches that border Lake Powell. From February 1981 through July 1981, R155 was located in Dark Canyon. However, during August 1981 through December 1981, R155 was located and observed in the Sheep Canyon area, approximately 6 airline miles southwest of Dark Canyon.

After December 1981, no radio signals were received from R155.

Extensive flights were made each month from January 1982 through November, 1982 to locate R155 but with no success. Collar malfunction is also suspected in this case.

Ram #148.316 (R316), now 6½ years old, was collared in Wilson Canyon February, 1982. Since that time R316 has not been located despite extensive telemetry flights to find him. The reason for our failure to locate him is still unclear, but again collar malfunction may be a factor as well as extensive movements by R316 beyond our search area.

R316 had a severely damaged knee joint of the right front leg (see photo section) that limited his mobility at the time of capture. This injury possibly lead to R316's death, however, no mortality signal has been received during any of the telemetry flights.

Ram #148.355 (R355), a 3½ year old, was captured west of Jacobs Chair Mesa and fitted with a collar February, 1982. However, on 25 March 1982 R355 was found dead near the capture site during a fixed-wing telemetry flight. R355 apparently died from peritonitis caused by the dart wound it received at the time of capture.

Ram #148.085 (R85), a 2½ year old, was captured in Cataract Canyon. February, 1981. He was located 7 times from February, 1981 through September, 1981 (Figure 6). Approximate home range size based on these locations was estimated to be 9.0 square miles. On 18 September 1981, R85 was found dead in Lean-to Canyon. The sheep had been killed by a cougar (Felis concolor) 3-4 days prior, and was approximately 95% consumed when the sheep was located.

Ewe #148.080 (E80), a mature ewe, was captured on a steep talus slope near the mouth of Dark Canyon February, 1982. Since that time, she has been located 12 times including fixed-wing telemetry flights, ground locations,

and boat locations (Figure 7). Approximate home range size based on these locations were estimated to be 9.0 square miles. During this time, E80 moved considerably. By May 1982, she had moved north into Slide Canyon presumably to lamb, but during the June telemetry flight E80 was located near the mouth of Sheep Canyon 7 airline miles to the southwest. E80 remained in the Sheep Canyon vicinity until September, 1982 when she moved back into the mouth of Dark Canyon. However, by 20 October, E80 had moved back into Sheep Canyon once again. On 25 October, E80 was located back near the mouth of Dark Canyon. E80 was observed wtih 2 ewes, 2 lambs, and 1 yearling ram during the summer (one lamb was hers — E80 did not have a lamb with her when collared February, 1982) but in October during the rut the group had been joined by 4 rams including a 7+ year old ram, (2) 5½ year old rams, and (1) 3½ year ram.

These sheep utilize the steep talus slopes and benches from the shore of Lake Powell to the 200-300 foot verticle cliffs below the rim of Cataract Canyon. Because of the ruggedness of the area, it is extremely difficult to locate and observe sheep for any length of time. However, use of a boat to travel up the lake allows somewhat easier location and observation of sheep in Cataract Canyon.

Ewe #148.115 (E115), a mature ewe, was captured in Mahon Canyon February, 1981. Since that time, E115 has been located 31 times including fixed-wing telemetry flights and ground locations (Figure 8). Approximate home range size based on these locations was estimated to be 7.0 square miles. During this period E115 was found almost exclusively on Chinle talus slopes and benches (96.7%), in the Shadscale-Galleta-Ephedra vegetation type (96.7%). and on southeast and northwest facing slopes (43.3% and 36.7% respectively, Table 2). E115 has moved relatively little since being collared in February,

1981. Her movements have been limited primarily to Mahon and Wilson Canyons with no apparent pattern. However, E115 has been located in Mahon Canyon in May and June both years during the lambing period. During the summer months in 1981, E115 was never observed with other sheep. However, during the rut in 1981-82 she was observed with several other rams and ewes. E115 has been observed with several ewes and young rams throughout 1982 including R75 in July 1982. E115 has not been observed with a lamb since she was collared February, 1981.

Ewe #148.145 (E145), a mature ewe, was captured in Blue Notch Canyon February, 1981. Since that time she has been located 39 times including fixed-wing telemetry flights and ground locations (Figure 9). Approximate home range size based on these locations was estimated to be 10.0 square miles. During this period E145 was found primarily on chinle talus slopes and benches (82.0%), in the Shadscale-Galleta-Ephedra vegetation type (69.2%), and on a majority of slope aspects in the area (Table 2).

E145 has shown a consistent pattern of movement during the past two years. During the spring (May-June during lambing season) and summer months when it is extremely hot and dry she has tended to stay near the spring at the mouth of Hidden Valley (a side branch of Blue Notch Canyon). Later in the year during periods of heaviest precipitation (August-September) she has moved from Hidden Valley across Blue Notch Canyon and around into Scourp Canyon above Lake Powell. Then as the rut approached in both 1981 and 1982 (early October), she and her associates moved back into Hidden Valley where they werejoined by rams of various ages for breeding.

During the past two field seasons, E145 has been associated with essentially the same group of ewes and lambs. The ewes are easily identified by their peculiarly tall, straight horns. E145 had a lamb in 1981, but has never been observed with a lamb in 1982.

Ewe #148.150 (E150), a mature ewe, was captured in left fork of Blue Canyon February, 1982. Since that time she has been located 13 times including fixed-wing telemetry flights and ground locations (Figure 10). Approximate home range size based on these locations was estimated to be 7.0 square miles. During this period, E150 was located primarily on Chinle talus slopes (92.3%), in the Shadscale-Gallenta-Ephedra amd Salina Wild Rye-Gallenta vegetation types (each 46.2%), and used primarily southeast and northwest facing slopes (Table 2). Since February 1982, E150 has remained almost exclusively in Blue Canyon including during lambing season and breeding season. She has on occasions moved into nearby Pocket and Piute Canyons but has not remained away from Blue Canyon for any significant periods.

E150 had no lamb when she was captured in February, 1982 and has not been observed with a lamb since lambing occurred last spring. She was observed in groups of sheep, including ewes, lambs, and young rams throughout the summer. When last observed 20 November, 1982, E150 and her associate ewes and lambs had been joined by several mature rams.

Ewe #148.200 (E200), a mature ewe, was captured February, 1982 west of Jacobs Chair Mesa. Since that time, she has been located 20 times including fixed-wing telemetry flights and ground locations (Figure 11). Approximate home range size based on these locations was estimated to be 15.0 square miles. During this period, E200 was located primarily on Moenkopi talus slopes and benches (45.0%), in the Pinon-Juniper and Blackbrush-Galleta vegetation types (50.0% and 40.0% respectively), and on all of the available slope aspects (Table 2). Prior to August 1982, E200 remained in the general area of her capture (including lambing season), however, in August and September (similar to E145), during heaviest precipitation E200 moved considerably. During August, 1982, E200 moved approximately 5 airline miles east to Jacobs

Chair Mesa a distance of 4 airline miles. During September, 1982, E200 moved approximately 3 airline miles to the southwest to the area where she was collared in February. By October, 1982, E200 moved back to the north where she was located during September. On 16 November she was again seen back to the southwest in the area where she was collared above Short Canyon. This great movement is not easily explained, but may be due in part to the abundance of water brought by fall rains. Sheep were not limited only to springs and seeps for water sources, but could use potholes and natural tanks as well.

E200 was seen in association with the same group of 10 sheep (6 ewes, 3 lambs, 1 yearling ram) from June, 1982 through September, 1982. In October, 1982, during the rut, the group was joined by R65 and 3 mature rams that were also seen in the same area duirng the rut of 1981. E200 did not have a lamb with her when captured in February, 1982, however, she has had a lamb since that time.

Ewe #148.345 and .365 (E345, E365), both mature ewes, were captured on Found Mesa February, 1982. Since that time, these 2 sheep have been located 22 times including fixed-wing telemetry flights and ground locations (Figure 12). In all but one instance, both sheep were observed together. The only time when they were not located together was 12 May 1982 during a telemetry flight. In all probability this was the isolation period during lambing for one or both of the ewes. Both sheep had lambs in 1982 in the Found Mesa area, while neither had a lamb with her in February, 1982 when both sheep were collared. Approximate home range size based on the 22 locations was estimated to be 8.0 square miles. During this period #345 and #365 were found primarily on Moenkopi talus slopes (40.9%), in the Pinon-Juniper vegetation type (72.7%), and on all available slope aspects (Table 2).

E345 and E365 occupied 3 different areas from February, 1982-October, 1982. The two ewes were captured on Found Mesa in February, 1982. However, by June both sheep had left Found Mesa and moved approximately 4 airline miles east to Lone Butte. Both sheep remained in the Lone Butte vicinity until July when they were located on Fry Point approximately 4 airline miles southwest of Lone Butte. This movement is particulary significant since these sheep and their associates (3 ewes, 5 lambs) crossed U.S. Highway 95. This is the first documentation of sheep crossing the highway since Bates et al. (1975) also discovered that sheep did cross the road. This case is particularly significant because when Bates et al. (1975) found sheep to be crossing the road, the road was unpaved. In 1976 the road was paved and now provides access through sheep habitat for thousands of vehicles annually.

The two ewes remained on Fry Point until 16 July 1982 when they were located back across the highway in the Lone Butte vicinity. On 29 July 1982, E345 and E365 were again located in the Lone Butte area, but by 19 August 1982, had moved back across the highway to Fry Point. E345 and E365 remained on Fry Point until 17 September 1982 when they moved from Fry Point back across U.S. Highway 95 and onto Lone Butte where they remained through October 1982.

During a helicopter census 20 November 1982, E345 and E365 were both located. They were not together when sighted. E345 was back on Found Mesa with 3 ewes, 4 lambs, and a mature ram, while E365 was in the Lone Butte area with her lamb.

Although the project is far from complete, the following trends in movement and habitat utilization by desert bighron sheep have been observed.

1. Rams have had larger average home ranges than ewes (Table 3).
2. Greatest ram movement has occurred prior to and following the rut.

3. Rams have tended to return to same areas to rut each year.

4. Ewe movements have tended to be greatest during late summer and early fall when precipitation is greatest.

5. Ewes have generally remained in the same area during the rut and are sought out by rams.

6. Ewes have returned to the same general area each year during lambing season.

7. Sheep have selected primarily talus slopes and benches, mixed brush-grass vegetation types, and have used a variety of slope aspects (Table 2).

In order to more fully evaluate these trends field research must be continued.

Forage Utilization

Diet selection of desert bighorn sheep in southeastern Utah has been monitored since July, 1981 through a direct observation technique (see photo section). During the period from July - September, 1981, bighorn sheep ate primarily browse (76.0%), particularly cliffrose, Cowania mexicana, and blackbrush, Coleogyne ramosissima, (32.7% and 23.2% respectively).

During the period from October-December, 1981, the diet of bighorn sheep was dominated by browse plants (70.3%); again blackbrush was the major diet item (66.53%). Although grasses only made up 27.9% of the diet during the October-December period, the increase from 18.3% during July-September, 1981 is significant. This rise in grasses in the diet can be attributed to utilization of new growth stimulated by significant late summer and fall rains.

During the period from July-September, 1982, browse and grass species were represented more equitably in desert bighorn diets (52.91% and 45.58% respectively). Major items in the diet were galleta grass, Hilaria jamesii (29.58%), blackbrush (22.94%), and cliffrose (16.75%). The reason why grasses are more represented during this period than they were in 1981 is unclear.

Summaries of diet selection by forage class and species from July 1981-September 1982 are included in Tables 4, 5, 6, 7, 8, and 9.

Colorado State University analyzed desert bighorn fecal material collected by BLM personnel (San Juan Resource Area, Monticello, Utah) for Winter 1979-80, Spring 1980, and Winter 1980-81 (Table 10). Results indicate that winter diets of the 2 years vary considerably, particularly in importance of forage class in the diet. Winter 1979-80 fecal samples were dominated

by browse plants (76.4%). while forbs (18.3%) and grasses (5.3%) were less common. However, Winter 1980-81 samples showed considerably different results. Forbs (34.6%) were followed by browse (30.5%) and grasses (17.2%) in order of importance. Also, and unknown seed occurred in 17.7% relative density for the Winter 1980-81 sample.

Spring 1980 samples were dominated by browse plants (61.3%), while grasses (28.0%) and forbs (10.7%) were less common. The significant increase in grass component of the diet is probably a result of spring green-up of grass species.

Comparison of the direct observation method and fecal material analysis shows considerable differences in both percent forage class in the diet as well as plant species in the diet. These discrepencies do not discredit either method, but suggest that both methods produce important information to the resource manager because of the new information each yields.

Forage utilization data collected during the period from Winter 1979 through Summer 1982 suggest that desert bighorn in southeastern Utah have highly variable diets between seasons and between years. It can be concluded, however, that desert sheep in southeastern Utah are primarily browsers. At various times of the year, particularly spring and fall after significant rains, grasses are also an important component of sheep diets.

Influence of Livestock

Conflict or potential conflict between domestic livestock and desert bighorn sheep is a major concern to wildife and land managers as well as livestock operators. If competition between livestock and bighorn is to occur, it will naturally be in those areas where restrictively high degrees or aerial and diet overlap of bighorn and livestock occur. Presently there are 3 cattle grazing allotments within the boundries of the desert bighorn sheep study area (Figure 13).

The Indian Creek allotment is divided into 3 pastures of which only the Beef Basin pasture (150 cattle from 16 November - 15 June) and the Dark Canyon pasture (200 cattle from 16 November - 15 June) lie within the study area. Because none of the radio-collared sheep utilize these areas, little time was spent in these areas analyzing conflicts. However, sightings of cattle during fixed-wing telemetry flights indicate that cattle do move into areas utilized by sheep and that potential for competition does exist (Figure 13). This competition is most likely to occur during winter months after snow falls that would allow cattle to move out onto the points overlooking the Colorado River and into areas used by desert bighorn.

The White Canyon allotment is presently managed under a year round pasture rotation system. The allotment is set at 450 cattle (4455 AUM's), however use during the 1981-82 grazing season was limited to approximately 260 cattle by the permitee. Most cattle use of bighorn habitat occurs during late fall through early spring when cattle are moved from summer ranges into the White Canyon area to winter.

During the period cattle are on winter range, the areas they utilize do infact overlap desert bighorn habitat. However, based on ground

observations and sightings during fixed-wing flights (Figure 13), it appears that the majority of cattle use is on valley floors and lower, gently sloping talus slopes (mainly blackbrush-pinon-juniper flats and chainings). No cases of cattle using mesa tops and upper talus slopes were observed during this period. However, cattle fecal material was found on mesa tops in several places above Short Canyon during spring, 1981 suggesting that cattle do get on the mesa tops and into areas used heavily by bighorn sheep (within home range boundries of E200 and R65).

During the period cattle were on winter range in the White Canyon area in 1981-82, no bighorn sheep were observed using any of the valley floors or lower talus slopes. All desert bighorn sightings were on mesa tops and higher talus slopes and benches. Bighorn have been observed or located on valley floors in the White Canyon area on 7 different occasions during summer months prior to arrival of cattle (including E200, E345, E365, R65 and associates). In November, 1982 during a helicopter census, 16 desert bighorn (E200, R65, and associates) were located on the valley floor in Long Canyon, however, no cattle were in that area then.

Lack of sightings of bighorn in areas used by cattle does not imply that cattle are excluding sheep or that sheep are avoiding cattle. There are undoubtedly cases that go unobserved as sheep move from mesa to mesa when they use valley floors in areas where there are cattle. This also does not imply that negative interactions between cattle and sheep do not occur. It does suggest, however, that much further research is required before the relationships between cattle and desert bighorn in this area are fully understood.

Cattle are run in the Red Canyon pasture of the Lake Canyon allotment only during even years. It is intended to be used only as a buffer pasture

for 50 cattle from 6 October to 28 February. However, during November, 1981 the permitee trespassed several cattle in Red Canyon so observations of habitat and forage use were made on 2 occasions before the trespass cattle were removed from the area (see photo section).

Cattle were located through Red Canyon to Lake Powell (Figure 13). However, cattle generally used the canyon bottoms and were usually in or near the river bed or in close proximity to reservoirs. On one occasion, 7 cattle were observed at the base of the Windgate Cliff of Mancos Mesa. The Chinle talus slope falling away enabled the cattle to ascend to a point just below the cliff to an area where bighorn have been seen previously.

No sheep were observed in close proximity to cattle while the trespass cattle were in Red Canyon. However, cattle were moved into the area during the sheep rut and several sheep were seen using valley floors in Blue, Piute, Rainbow, Mahon, and Wilson Canyons that drain into Red Canyon so it is possible that cattle and sheep did come into contact.

Direct observations were made of feeding cattle in the Red Canyon and White Canyon areas in November on 200 feeding instances, cattle selected 71.5% grasses (primarily cheatgrass, Bromus tectorum, 46.0%), 22.5% browse plants (primarily 4-wing saltbush, Atriplex canescens, 6.5% and shadscale, A. confertifolia, 5.5%), and 6.0% forbs (Table 11).

Results of cattle fecal analysis (conducted at Colorado State University) duirng Winter 1979-80, Spring 1980, Winter 1980-81 for the White Canyon area indicate that cattle used a high percentage of browse plants during Winter 1979-80 (85.9%) and Winter 1980-81 (82.3%). Spring 1980 results showed the proportion of browse in cattle diets decreased to 55.6%, while grasses increased to 36.4% reflecting the spring growth of grasses (Table 12).

Analysis of diets indicates there is considerable overlap in diet components between desert bighorn sheep and cattle. Based on direct observation of feeding instances during late fall-early winter, cattle shared 72.7% (8 of 11) of all desert bighorn diet items, while bighorn shared 61.5% (8 of 13) of all cattle diet items.

Based on results of fecal material analysis during Winter 1979-80, cattle shared 57.9% (11 of 19) of all bighorn diet items, while bighorn shared 78.6% (11 of 14) of all cattle diet items. During Spring 1980 cattle and bighorn shared 68.8% (11 of 16) of each others diets. During Winter 1980-81 both cattle and bighorn shared 53.8% (7 of 13) of each others diet items.

Infludence of Mining

During the 1982 field season (June - November) very little mining activity occurred within the BLM desert bighorn sheep study area. This can be attributed to the current low price of uranium ore. Several truckloads of stock piled ore were hauled out of Red Canyon from the Markey Mine, however, no active mining occurred at any of the other previously active mines. Some assessment work (e.g., road improvement in Red Canyon and Piute Pass with a bulldozer) did occur within the area as well as some drilling and exploration (Figure 14).

After 3 July 1982, Petty-Ray Geophysical Exploration spent approximately one week at the upper end of Cheesebox Canyon and on Deer Flats (Figure 14) doing seismographic testing, including some drilling and surface blasting. It is not clear what effect this activity had on desert bighorn sheep in the area. However, radio-collared ewes, E345 and E365 were located in the Lone Butte-Hideout Canyon vicinity, an area approximately 2-3 airline miles from where the seismic activity took place. From June through the first week of July, prior to the seismic activity, E345 and E365 occupied the Lone Butte-Hideout Canyon area. On 9 July, during a fixed-wing telemtry E345 and E365 were located on Fry Point approximately 4 airline miles southwest of Lone Butte. Whether the blasting caused the sheep to vacate the Lone Butte area or rather the sheep moved due to natural motivations is not known.

Atlas Mineral Company spent approximately 1 month (late August-late September 1982) drilling on the top of the Windgate Mesa above Blue Canyon (Figure 14). No radio-collared sheep were located in these areas so the effect, if any the drilling had on the sheep in the area is unknown. The

drilling continued through the first week of the desert bighorn hunt. Hunters that hunted in the area where drilling took place reported seeing 2 sheep within 1 mile of an active drill site. Several fresh sets of sheep tracks were observed within a few hundred yards of several other drill sites by sheep hunters.

Minetome Mining Company did some exploratory driling of Fry Point (see photo section) 15-22 September 1982 (Figure 14). On 15 September, 10 sheep (including E345 and E365) were located during a fixed-wing telemetry flight. The sheep were located on the north side of the point early in the morning. By early afternoon the sheep had moved around the point to a location approximately one-half mile south of where the Minetome drill rig had been driling since 11:00 a.m. that morning. The sheep remained in this general area until 17 September when they moved up onto the mesa top and crossed within 50 yards of the inactive drill rig. The sheep were located by the researcher that afternoon while the sheep were still on top of the mesa. The sheep were approached to within 50 yards before the sheep discovered the researcher. The sheep took immediate flight and were located the next day, 18 September, 4 miles north on Lone Butte. The sheep were definitely disturbed by the researchers presence but whether the drilling activity had affected the sheep is not clear. However, the associated human activity at drill rigs may be disturbing to sheep if workers come in close contact with sheep.

Influence of Recreation

The effects of recreation on desert bighorn sheep are extremely difficult to assess. The area is very remote and in most cases, areas used by bighorn sheep are inaccessable without a 4-wheel drive vehicle or boat. Because of the ruggedness of the area, it does not receive as much recreational pressure as areas with better access. However, there are a few recreationists that take advantage of the area's remoteness to engage in various recreational activities in relative solitude.

The major recreational activites that occur in the area are backpacking -hiking, boating-fishing, hunting and off-road vehicle touring. Most of these activities occur during spring and fall periods when air temperatures are more favorable than during temperature extremes of summer and winter periods.

Though private individuals engage in backpacking and camping in bighorn sheep habitats, major sources or recreational activity are wilderness schools that teach camping and survival skills to relatively large groups of people for extended periods of time. During 1982, 12 wilderness school groups (281 people) used BLM lands in or in close proximity to desert bighorn habitat (Table 13). This number of people and groups has increased since 1978 (Table 14). Because wilderness school groups utilize bighorn sheep habitats primarily in spring and fall months, there is potential for human disturbance to sheep during lambing and breeding seasons.

Float trips, private and commercial, through Cataract Canyon are very popular with recreationists. These trips down the Colorado River take thousands of people through miles of bighorn sheep habitat every year. Data collected since 1976 demonstrate the number of trips/year and passengers/

year is generally increasing (Table 15).

A majority of the trips in 1982 were taken between May and September (Table 16) when weather conditions were favorable. The large number of trips and passengers in May and June create potential for human disturbance during the lambing season. The degree of disturbance is probably dependent on how aggressive boaters are to the sheep.

The researcher observed 15 interactions between boaters and sheep in Cataract Canyon. In 86.7% (13 of 15) of the interactions, sheep reacted only to the boats presence by watching the boats as they passed; boaters probably didn't see the sheep. In 13.3% (2 of 15) of the interactions, boats stopped and passengers got out of boats to watch sheep. In both cases, even though the boaters were more than 300 yards away, the sheep left the area. In one instance the sheep walked to a place out of the boaters view approximately ¼ mile away, however, in the other case the sheep ran excitedly up the steep talus slopes of the canyon to the rims high above the river (approximately 2 miles).

Another potential problem that exists as a result of float trips through Cataract Canyon is the possible exclusion of sheep from watering areas or at least interuptions of alterations in normal drinking patterns. A majority of the float trips occur from June-July (Table 16), the time when temperatures are highest and water is in most demand by the animals. Excessive use of critical water sources by boaters may prevent sheep from getting adequate water or may force sheep to use watering areas during unfavorable periods of the day. These types of problems are likely to occur at various campsites along the river (e.g. Imperial Valley, Gypsum Canyon, Sheep Canyon, etc.).

If float trips increase later in the year, particularly in October and November some conflict may arise between sheep and people during the

rut. The problem of boater and sheep interactions is one that needs to be examined in much more detail.

The 1982 desert bighorn sheep hunt, a trophy hunt, was held from 18 September-17 October. Ten permits were issued, 2 in Potash Unit (not within the BLM study area), 3 in the North San Juan Unit, and 5 in the South San Juan Unit (Figure 15). One special permit was auctioned to the highest bidder for $22,500.00. This money is used by Utah Division of Wildlife Resources for bighorn sheep transplant operations within the State. The successful applicant has the priviledge of hunting in any of the 3 units anytime from the beginning of the sheep season through the end of December.

Both hunters in the Potash Unit were successful in taking rams. The hunters in the North San Juan Unit failed to harvest any sheep. In the South San Juan Unit, 3 of 5 permit holders were successful in killing legal rams. The high-bid hunter has not yet started his hunt. A total of 5 sheep have been harvested to date this season.

The impact the bighorn sheep hunter imposes on the sheep population is in all probability greater than the removal of mature male sheep from the population. However, just how great the impact is, is unkown. Observation of sheep hunters in the Red Canyon area during the 1982 give some insight into possible effects of hunting bighorn sheep.

During the hunt, sheep habitat is entered by hunters, their associates, and the vehicles used during the trip. For example, from questionnaires answered by desert bighorn sheep hunters, it was calculated that during the 1981 hunt in the South San Juan Unit there were 93 hunter days and 14 vehicles in the South San Juan Unit. Though these numbers are by no means overwhelming, they probably exceed the human intrusion into the area for the summer months prior to the hunt. The hunters tend to

concentrate their activities to certain areas where sheep are consistently seen and killed, so in reality they concentrate their efforts in a relatively small area. This concentrated effort in a few key areas may have considerable effects on sheep.

During the 1981 hunt, hunters did not hunt significantly in areas used by radio-collared sheep. As a result no major movements of sheep were observed. However, in 1982 hunters spent a considerable period of time hunting in close proximity to E115. This provided an opportunity to follow E115 movements in relationship to hunters.

Three groups of hunters hunted in Mahon, Wilson, and Kathy's Canyons near where #115 was located. Prior to the hunt on 15 September 1982, E115 was located in Mahon Canyon during a fixed-wing telemetry flight (location #24, Figure 8). On 3 October, 4 hunters hiked into Mahon Canyon. They reported seeing E115 and her associates near the canyon mouth (location #25, Figure 8). They also reported that E115 and the sheep that were with her moved cautiously away from them towards the head of Mahon Canyon. On 10 October 1982, the same 4 hunters went back into Mahon Canyon and worked their way to the head of Mahon Canyon where they again spotted E115 (location #26, Figure 8). One of the hunters fired at and killed a trophy ram near E115 and her associates. The hunters reported that E115 and the other sheep that were with her ran completely out of the canyon. On 14 October, 2 hunters spotted E115 in Wilson Canyon (location #27, Figure 8) approximately 1 mile into the canyon. That same day these hunters killed a ram approximately 2 miles into the canyon, but they made no mention of how E115 reacted to the shooting. On 15 October, 2 different hunters spotted E115 near the mouth of Wilson Canyon (location #28, Figure 8). They reported that E115 and the sheep that were with her moved quickly to the canyon bottom

and toward Kathy's Canyon. On 16 October, the same 2 hunters reported seeing #115 in the mouth of Blue Notch Canyon (location #29, Figure 8). They reported that when E115 and the sheep that were with her saw them, they moved back towards Kathy's Canyon. On 17 October, the last day of the bighorn hunt, the same 2 hunters reported seeing E115 in Kathy's Canyon (location #30, Figure 8). Just after the hunt, 20 October, during a fixed-wing telemetry flight, E115 was located in Kathy's Canyon near where the hunters had last seen her (location #31, Figure 8). On 20 November during a helicopter census E115 was located back in Mahon Canyon (location #32, Figure 8).

The repeated disturbance to #115 by hunters caused her to leave Mahon Canyon, where she had spent a majority of the summer and move approximately 8 miles into the mouth of Blue Notch Canyon. Although E115 was disturbed enought to leave Mahon Canyon, she apparently was not disturbed enough to cause her to vacate the canyon permanently. The sequence of events may give us some insight into what happens if desert bighorn are exposed to repeated disturbance over extended periods of time.

Influence of Other Human Disturbances

Aircraft

Sheep response to fixed-wing aircraft flights was observed on 27 occasions. All classes of sheep in medium (2-7) to large (7+) size groups were observed as planes flew overhead of the sheep. Because the sample size is small, data were not analyzed statistically. However, general trends were identified in sheep reaction patterns.

A majority (56.6%, 15 of 27) of overhead passes by fixed-wing aircraft resulted in little or no reaction from the sheep. All of these cases occurred at plane distances greater than 300 yards above the sheep. Twenty-six percent (7 of 27) of the cases resulted in moderate response of sheep to overhead flight by planes; in all cases planes were greater than 300 yards above the sheep. Only 18.5% (5 of 27) of the observed interactions between aircraft and sheep resulted in extreme response. A major proportion of these cases (4 of 5) occurred when planes flew below 300 yards above ground. This suggests that low flight (0-300 yards above ground) by fixed-wing aircraft through desert bighorn habitat may be putting undue stress on resident sheep.

Since initial response of sheep to plane could not be observed from the aircraft, fixed-wing telemetry flights have not been considered with the 27 other cases. However, sheep reaction during telemetry flights as observed from the plane also suggests that aircraft can have a stressful impact on sheep.

In order to determine location of sheep as accurately as possible, telemetry flights are often made very close to the ground (below 100 yards above ground). The reaction sheep exhibit to such low flights generally

fall into 2 major categories. Sheep either remain motionless or move slightly to cover under trees, boulders, rock overhangs, etc. or they flee hurriedly away from the plane. Though excited flight by sheep through steep, precipitous terrain is no doubt the most stressful of the 2 categories, hiding by sheep is also stressful. Heart rates are elevated (MacArthur et al. 1979) and normal behavior patterns are interupted considerably.

Similar reactions by sheep have been observed in response to low flying helicopters. During helicopter census, transplants, and collaring operations, sheep have been observed to seek cover as well as flee. On 2 occasions, the researcher was able to observe sheep reaction to low flight (0-100 yards above ground) by helicopter. In one case, despite numerous low passes by the helicopter over the sheep, the sheep remained hidden under a rock overhang. In the other case, as sheep were approached by the helicopter, they fled hurriedly across rugged talus slopes for a distance of approximately 3/4 miles before the helicopter vacated the area.

Because helicopters are so manuverable, they have the potential to harass bighorn sheep to a greater extent than any other disturbance. When chased with a helicopter sheep will often run miles before stopping to rest. When E200 was collared in February, 1981 she ran approximately 10 minutes and 5 miles in extremely rugged terrain before she stopped long enough to dart her. It is important that helicopter use in the area be monitored to prevent undue harassment.

Vehicles

Sheep response to disturbance by vehicles was observed on 30 occasions. All classes of sheep, all group sizes, at all distances were observed. Though sample size was too small for statistical analysis, general trends can be identified. In 63.3% of the cases (19 of 30), little to no overt response was exhibited by the sheep. The majority of these cases occurred when distance of sheep away from disturbance was greater than 300 yards (14 of 19, 74%). Of the remaining 5 cases, 4 occurred when the vehicle was between 75 and 300 yards away from the sheep.

In 26.7% of the cases (8 of 30) sheep response was moderate. These responses occurred primarily when sheep were farther than 300 yards away (4 of 8, 50%) or between 75-300 yards away (3 of 8, 37.5%). Only 10% of the responses by sheep were extreme (3 of 30). All 3 cases occurred when sheep were approached by vehicles between 0-75 yards. There appears to be an inverse relationship between distance and severity of response by sheep. As distance from disturbance decreases, severity of sheep response tends to increase.

Hikers

Sheep response to hikers has been observed on 68 occasions. These data were analyzed statistically (3 X 3 Contingency table) to determine what relationships exist between group size, group composition, distance to disturbance and severity of response by sheep (Table 17). Analysis indicated that distance to disturbance and sheep response were independent of each other (x^2 = 1.69, 4df). However, sheep response was dependent on both group composition (x^2 = 12.41, 4df) and group size (x^2 = 11.23, 4df). This suggests that mixed groups of sheep and large groups of sheep respond less extremely to hikers than small groups of sheep. Though these conditions are both significant, the sample size is still relatively small. More data along these lines must be collected before critical judgements can be made.

Sheep response to hikers is an important category to be considered. No only does hiking apply to recreation, but hiking also goes hand-in-hand with mining operations, and livestock operations. These data probably can be generalized to all such activities because sheep no doubt have difficulty in differentiating between activities.

Disease Information

During capture, collar and transplant operations conducted by Utah Division of Wildlife Resources February, 1982, blood samples were collected from 31 desert bighorn sheep in southeastern Utah. Samples were tested to determine if titers for Brucellosis, Leptospirosis, Anaplasmosis, and Blue Tongue diseases were present in any captured sheep.

All of samples were negative for Leptospirosis and Anaplasmosis, however, two very light titers for Brucellosis were detected. Ten of 31 samples tested positive for Blue Tongue disease although no clinical signs of the disease were observed in any of the captured sheep.

One ram harvested during the desert bighorn hunt was infested with ear mites (see photo section). Both ears were completely plugged with tissue and hardened serum. It is unlikely with such a degree of plugging that the ram could hear very well.

No sheep captured during the collaring operation in February, 1982 in the BLM study area exhibited any symptoms of Desert Bighorn Chronic Sinusitis. However, two rams captured in Canyonlands National Park were severely infected with sinusitis. One of the rams died during capture, but the other was sent to Glaze Veterinary Clinic, Kerville, Texas for further study.

On 20 September 1982, while observing E145 and her associates in Scourp Canyon, the researcher observed that 8 of 12 sheep (including 3 yearling rams, 1 yearling ewe, 4 mature ewes) in the group were infected with some kind of mouth disease. The muzzle region was covered with blisters or pustules that varied in size from very small to some that were the size of a pea. Other symptoms included scabs on lips, chin, and below nostrils, open sores in the same areas, heavy mucous drainage, and in extreme cases severe swelling

of upper and lower lips as well as the chin area (see photo section).

The very severely infected sheep (extremely swollen lips) had some difficulty in eating, especially biting off plant parts. The severely infected sheep also were more lethargic than mildly infected sheep.

The sheep were observed 22-25 September and 10, 19 October to monitor progress of the disease. The disease did not progress any further and the sheep eventually returned to normal vigor. By 19 October, 1982, all symptoms of the disease were gone from the sheep and all appeared vigorous and healthy. One of the bighorn hunters observed a young ram in Wilson Canyon that exhibited similar symptoms 17 October 1982.

The actual disease that infected the sheep is not known. After hearing the description of symptoms and observing pictures of infected sheep, Dr. Tom Bunch, Utah State University, and Dr. Richard Hedelius, U.S. Department of Agriculture Veterinarian, both concluded that the disease was most likely 1 of 3 viral diseases that have indistinguishable clinical symptoms. The 3 likely diseases were Vesicular Stomatitis, Blue Tongue, or Contageous Ecthyma (sore mouth).

During the period when the sheep were infected, there was a wave of Vesicular Stomatitis across the western U.S. from Texas to Montana. This evidence suggests that the sheep may have been infected with Vesicular Stomatitis. However, positive diagnosis can not be made without blood analysis to isolate the virus or titer levels.

During phase 3 of the study, blood samples collected from captured sheep will also be tested for Vesicular Stomatitis and Contageous Ecthyma to determine if sheep have been exposed to either one of those diseases.

Discussion and Recommendations

Since February 1981, radio-collared desert bighorn sheep have been observed on BLM lands in southeastern Utah. During that time, data has been collected regarding several aspects of desert bighorn sheep ecology. Movements, habitat utilization, influence of livestock, influence of mining, and influence of recreation on bighorn sheep have been monitored.

The desert sheep in southeastern Utah are similar to other wild sheep populations with respect to movements. Sheep within the study area exhibit seasonal movements, particularly rams as they move to and from rutting areas. Some ewes also show a tendency to return to the same area to lamb each year. Rams generally have larger home ranges than ewes, however, both rams and ewes utilize considerable tracts of land throughout the year. This is important from a management perspective because evaluation of future development in the area must consider the large areas used by an individual animal. Large blocks of land should be maintained in critical sheep habitat areas to prevent barriers to movement from developing.

It was discovered during the second phase of the study that sheep were crossing back and forth across U.S. Highway 95. This situation warrants further study. It is important to determine how fluctuations in traffic levels will effect willingness of sheep to cross the highway. A monitoring program consisting of recording traffic volume and desert bighorn locations, in response to that level should be initiated so data will be available to help determine if increased traffic will be a barrier to sheep movements.

Diet selection by desert bighorn in southeastern Utah has proven to be variable between seasons of the year as well as between years. Sheep are primarily browsers, but use considerable quantities of grass during some

seasons. During the first two phases of the study, fecal material has been collected from all regions within the study area. These samples should be analyzed to determine how diets compare in different areas as well as different seasons. This data will augment direct observation feeding data that have been collected to this point.

To this point in the study, little actual time has been spent in observing interactions between cattle and desert bighorn sheep. However, during Winter 1982-83 and Spring 1983, intensified efforts will be made to evaluate possible competitive interactions. The data collected to this point indicate some overlap in diet as well as habitat types used by sheep and cattle. These areas of overlap need to be studied carefully to determine full extent of the interactions. Particular areas of interest are how much use of valley floors by bighorn when cattle are in the area, and how much use of mesa tops is there by cattle in the White Canyon area.

There has been little mining activity in the area to this point. Observations of interactions between sheep and mining activites have been mostly fortuitous. It is important that BLM personnel continue to let the researchers know when any activities will be occurring in the area so they can be monitored.

Much more information regarding recreation influences on bighorn sheep is needed. A monitoring process should be initiated particularly to determine how much traffic there is throughout the year in citical sheep habitat areas. Further information will be collected in subsequent phases of the study to determine impacts of hikers, hunters, and boaters.

Though the data for interactions between aircraft are minimal to this point, the responses of sheep to low aircraft flight are extreme enough to indicate that low aircraft flights in sheep habitat are potentially

very stressful. Fixed-wing flights and more particularly helicopter flights should be carefully monitored in critical sheep habitat areas. Low flights should be restricted during critical periods to the sheep (i.e. lambing, breeding seasons, etc.).

The sheep in the BLM study areas are relatively free from serious disease problems. However, the discovery of a mouth disease during 1982 indicates that the sheep are not immune to problems. All wildlife and land managers should become aware of the symptoms of various diseases so problems can be recognized if observed.

Experienced and Anticipated Problems

During phase 2 of the study relatively few serious problems were encountered. The most serious problems experienced were inability to collar more than 7 sheep and failure of several ram radio-collars. Concentrated efforts were made to collar sheep in the Beef Basin-Gypsum Canyon areas of the study area. However, severe weather conditions and low sheep numbers prevented capturing any sheep in those areas.

Reasons for ram collar failure are not known. Failures have reduced active ram collars from 5 to 1. This leaves some serious gaps in necessary data for the study. Additional rams must be collared to document their movements and habitat use patterns. Sufficient ewes are collared to carry through the remainder of the study.

Minor problems experienced include a number of minor truck repairs early in the summer, and no phone at Fry Canyon. On 1 September 1982, a new vehicle was obtained from the UDWR. Since then no truck problems have been experienced. Because there is no phone at Fry Canyon, communication with BLM and other agency personnel is very difficult. It might be advantageous to make a radio available to the project, if for no other reason than for emergency communications.

No major problems are anticipated in the future. All agencies involved in the project have cooperated to make the field work flow as smoothly as possible.

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APPENDICES

TABLES

Table 1. Sex, age, and primary location of radio-collared sheep on BLM lands in southeastern Utah.

No.	Sex	Age	Year Collared	General Location
R65	M	3½	1981	Jacobs Chair Mesa
R75	M	3½	1981	Wilson Canyon
R85*	M	2½	1981	Dark Canyon
R135	M	2½	1981	Blue Notch Canyon
R155	M	2½	1981	Sheep Canyon
R316	M	6½	1982	Wilson Canyon
R355**	M	3½	1982	Short Canyon
E80	F	Mature	1982	Sheep Canyon
E115	F	Mature	1981	Mahon Canyon
E145	F	Mature	1981	Blue Notch Canyon
E150	F	Mature	1982	Blue Canyon
E200	F	Mature	1982	Short Canyon
E345	F	Mature	1982	Found Mesa
E365	F	Mature	1982	Lone Butte

* R85 was killed September 1981 by a mountain lion.

** R355 died approximately 4-6 weeks after being collared in February 1982.

Table 2. Use of topography type, vegetation type, and slope aspect by radio-collared desert bighorn sheep in southeastern Utah. Number in front of parentheses is number of observations of that collared sheep; number in parentheses is percent of total observations of that sheep.

Topography type	Collared Sheep Number							
	R65	R75	R135	E115	E145	E150	E200	E345 E365
Mesa top	4(13.8)	3(9.7)	1(3.7)	0(0)	1(2.6)	0(0)	6(30.0)	4(18.2)
Chinle talus Chinle bench	6(20.7)	$\frac{17}{6}$(74.2)	$\frac{14}{8}$(81.5)	$\frac{20}{10}$(96.8)	$\frac{24}{8}$(82.0)	12(92.3)	5(25.0)	5(22.7)
Moenkopi talus Moenkopi bench	$\frac{8}{8}$(55.2)	$\frac{0}{0}$(0)	3(11.1)	$\frac{0}{0}$(0)	$\frac{0}{0}$(0)	1(7.7)	$\frac{8}{1}$(45.0)	9(40.9)
Valley floor	3(10.3)	5(16.1)	1(3.7)	1(3.2)	6(15.4)	0(0)	0(0)	4(18.2)
	29(100.0)	31(100.0)	27(100.0)	31(100.0)	39(100.0)	13(100.0)	20(100.0)	22(100.0)
Vegetation type								
Blackbrush-Galleta	15(51.7)	5(16.1)	4(14.8)	1(3.2)	10(25.6)	1(7.6)	8(40.0)	1(4.5)
Shadscale-Galleta-Ephedra	5(17.3)	23(74.2)	16(59.3)	30(96.8)	27(69.2)	6(46.2)	2(10.0)	5(22.8)
Pinon-Juniper	9(31.0)	3(9.7)	1(3.7)	0(0)	1(2.6)	0(0)	10(50.0)	16(72.7)

Table 2. (Continued)

Vegetation type (Continued)	Collared Sheep Number							
	R65	R75	R135	E115	E145	E150	E200	E345 E365
Salina Wild Rye-Galleta	0(0)	0(0)	6(22.0)	0(0)	1(2.6)	6(46.2)	0(0)	0(0)
	29(100.0)	31(100.0)	27(100.0)	31(100.0)	39(100.0)	13(100.0)	20(100.0)	22(100.0)
Slope aspect								
South facing	4(13.8)	5(16.1)	5(18.5)	0(0)	18(46.2)	2(15.3)	4(20.0)	2(9.1)
North facing	2(7.0)	1(3.2)	4(14.8)	0(0)	1(2.6)	0(0)	1(5.0)	1(4.5)
East facing	3(10.3)	0(0)	0(0)	0(0)	0(0)	0(0)	2(10.0)	1(4.5)
West facing	6(20.7)	2(6.5)	2(7.4)	5(16.1)	8(20.5)	0(0)	4(20.0)	2(9.1)
Southeast facing	6(20.7)	11(35.5)	12(44.5)	14(45.2)	8(20.5)	5(38.5)	2(10.0)	2(9.1)
Southwest facing	5(17.2)	3(9.7)	1(3.7)	1(3.2)	2(5.1)	0(0)	1(5.0)	8(36.4)

Table 2. (Continued)

Slope aspect (Continued)	Collared Sheep Number							
	R65	R75	R135	E115	E145	E150	E200	E345 E365
Northeast facing	0(0)	0(0)	2(7.4)	0(0)	0(0)	0(0)	1(5.0)	5(22.8)
Northwest facing	3(10.3)	9(29.0)	1(3.7)	11(35.5)	2(5.1)	6(46.2)	5(25.0)	1(4.5)
	29(100.0)	31(100.0)	27(100.0)	31(100.0)	39(100.0)	13(100.0)	20(100.0)	22(100.0)

Table 3. Estimated home range sizes for radio-collared desert bighorn sheep on BLM lands in southeastern Utah (1981-1982).

Sex	Age	Number	Location	No. Locations	Home range size (square miles)
M	3½	R65	Jacobs Chair	29	12.0
M	3½	R75	Wilson Canyon	31	25.0
M	2½	R85	Dark Canyon	7	9.0
M	2½	R135	Blue Notch	27	41.0
M	2½	R155	Sheep Canyon	15	14.0
				Average	20.2
F	Mature	E80	Sheep Canyon	12	9.0
F	Mature	E115	Mahon Canyon	31	7.0
F	Mature	E145	Blue Notch	39	10.0
F	Mature	E150	Blue Canyon	13	7.0
F	Mature	E200	Short Canyon	20	15.0
F	Mature	E345	Found Mesa	22	8.0
F	Mature	E365	Lone Butte	22	8.0
				Average	9.14

Table 4. Plant species selected by desert bighorn sheep in southeastern Utah, July - September 1981 (direct observation).

Plant Species	No. Feeding Instances	% Total
Cliffrose	196	32.7
Blackbrush	139	23.2
Shadscale	95	15.8
Galleta grass	43	7.1
Skunkbush	41	6.8
Unidentified grasses	52	8.6
Unidentified forbs	34	5.7
TOTAL	600	100.0

Table 5. Diet composition of desert bighorn by forage class in southeastern Utah, July - September 1982 (direct observation of 600 feeding instances).

Forage Class	No. Feeding Instances	% Total
Grass	95	15.8
Browse	471	78.5
Forbs	34	5.7
TOTAL	600	100.0

Table 6. Plant species selected by desert bighorn in southeastern Utah October - December 1981 (direct observation).

Plant Species	No. Feeding Instances	% Total
Blackbrush	1,470	65.30
Indian rice grass	291	12.93
Cheatgrass	202	8.97
Cliffrose	86	3.82
Galleta grass	80	3.55
Salina wild rye	35	1.55
Ephedra	14	0.62
Rabbitbrush	3	0.13
Juniper	1	0.04
Shadscale	1	0.04
Desert trumpet	1	0.04
Unidentified grass	20	0.89
Unidentified browse	8	0.36
Unidentified forbs	39	1.73
TOTAL	2,251	100.00

Table 7. Diet composition of desert bighorn by forage class in southeastern Utah, October - December 1981 (direct observation of 2,251 feeding instances).

Forage Class	No. Feeding Instances	% Total
Grass	628	27.91
Browse	1,583	70.29
Forbs	40	1.80
TOTAL	2,251	100.00

Table 8. Plant species selected by desert bighorn in southeastern Utah, July - September 1982 (direct observation).

Plant Species	No. Feeding Instances	% Total
Galleta grass	392	29.58
Blackbrush	304	22.94
Cliffrose	222	16.75
Salina wild rye	61	4.60
Cheatgrass	57	4.30
Singe leaf ash	53	4.00
Indian rice grass	29	2.19
Squawbush	16	1.21
Ephedra	11	0.83
Snakeweed	9	0.68
Desert trumpet	4	0.30
Rabbitbrush	4	0.30
Shadscale	3	0.23
Globe mallow	3	0.23
Serviceberry	3	0.23
Princes plume	1	0.08
Unidentified grass	65	4.91
Unidentified browse	76	5.74
Unidentified forbs	12	0.91
TOTAL	1,325	100.00

Table 9. Diet composition of desert bighorn by forage class in southeastern Utah, July-September 1982 (direct observation of 1,325 feeding instances).

Forage Class	No. Feeding Instances	% Total
Grass	604	45.58
Browse	701	52.91
Forbs	20	1.51
TOTAL	1,325	100.00

Table 10. Results of desert bighorn fecal material analysis conducted by Colorado State University for BLM (San Juan Resource Area): Winter 1979-1980, Spring 1980, and Winter 1980-1981.

Plant	Percent Relative Densities		
	Winter 1979-80	Spring 1980	Winter 1980-81
Bromus	1.4	8.2	8.8
Elymus	0.3	9.1	0.8
Festuca	0.2	0.0	0.0
Hilaria	3.3	9.3	0.8
Oryzopsis	0.0	1.2	0.8
Vulpia	0.0	0.0	3.0
Stipa	0.1	0.2	3.0
Total grasses	5.3	28.0	17.2
Descuriana	1.0	0.3	0.0
Lesquerella	8.0	1.1	34.6
Mentzelia	0.2	0.0	0.0
Phoradendron	0.1	0.0	0.0
Sphaeralcea	8.9	9.3	0.0
Unknown forb	0.1	0.0	0.0
Total forbs	18.3	10.7	34.6
Artemisia	1.0	0.3	0.8
Atriplex	6.4	3.2	0.0
Ceratoides	0.4	0.0	0.8
Cercocarpus	24.0	24.6	6.2
Coleogyne	24.7	6.6	13.1
Cowania	16.0	16.3	0.0

Table 10. (Continued)

Plant	Percent Relative Densities		
	Winter 1979-80	Spring 1980	Winter 1980-81
Ephedra	3.2	9.8	9.6
Shepherdia	0.7	0.3	0.0
Pinus	0.0	0.2	0.0
Total browse	76.4	61.3	30.5
Unknown seed (probably a mustard			17.7

Table 11. Diet composition of cattle in the desert bighorn sheep study area November - December 1981 (based on 200 direct observations of 20 feeding cattle).

Plant	No. Feeding Instances	% Total
Grasses		
Cheatgrass	92	46.0
Galleta grass	28	12.0
Indian rice grass	23	10.0
Total grasses	142	71.5
Browse		
4-wing saltbush	13	6.5
Shadscale	11	5.5
Blackbrush	7	3.5
Ephedra	7	3.5
Tamarisk	4	2.0
Rabbitbrush	1	0.5
Sagebrush	1	0.5
Snakeweed	1	0.5
Total browse	45	22.5
Forbs		
Unidentified forb	9	4.5
Desert trumpet	2	1.0
Thistle	1	0.5
Total forbs	12	6.0
Total	200	100.0

Table 12. Diet composition for cattle in the BLM bighorn sheep study area for Winter 1979-80, Spring 1980, Winter 1980-81 (determined by fecal analysis conducted at Colorado State University).

	Relative Percent Densities		
Plant	Winter 1979-80	Spring 1980	Winter 1980-81
Bromus	3.2	0.4	7.2
Elymus	0.0	1.1	0.0
Festuca	0.2	0.0	0.0
Hilaria	5.2	34.5	2.6
Sporobolus	0.8	0.4	0.8
Total grasses	9.2	36.4	10.6
Astragalus	0.0	0.0	0.9
Descuriana	0.2	0.0	0.0
Lesquerella	0.0	0.6	0.0
Sphaeralcea	4.5	7.4	5.3
Unknown forb	0.2	0.0	0.0
Total forbs	4.9	8.0	6.2
Artemisia	0.3	1.8	0.9
Atriplex	50.3	6.7	27.0
Ceratoides	2.1	0.1	0.0
Cercocarpus	4.3	11.1	5.3
Chrysothamnus	0.2	0.0	0.0
Coleogyne	12.4	14.1	10.0
Cowania	4.5	5.8	5.3
Dalea	0.0	1.2	0.0
Ephedra	11.8	13.0	33.0
Eriogonum	0.0	0.9	0.0

Table 12. (Continued)

Plant	Relative Percent Densities		
	Winter 1979-80	Spring 1980	Winter 1980-81
Sarcobatus	0.0	0.9	0.0
Shepherdia	0.0	0.0	0.8
Total browse	85.9	55.6	82.3
Unknown seed			0.9

Table 13. Wilderness school use of BLM lands within the bighorn sheep study area, 1982. Data from National Park Service records, Moab, Utah.

Group	Dates	No. People	Areas Used
Enviros	1/11, 12, 16	13	Beef Basin
Enviros	2/16, 17	13	Beef Basin, Ruin Park
Nat. Outdoor Leadership School	2/9-24	20	Dark Canyon, Lost Canyon, Butler Wash, House Park, Fable Valley, Youngs Canyon, Ruin Canyon, Fort Kncker Canyon, White Canyon
Nat. Outdoor Leadership School	2/19-24	40	Upper Gypsum Canyon, Fable Valley, Sweet Alice, Beef Basin
Enviros	3/3, 4	13	Beef Basin, Ruin Canyon
Colo. Outward Bound School	3/6, 7	25	Butler Wash
Colo. Outward Bound School	5/10-18	11	Sweet Alice, Young's Canyon, Dark Canyon, Lean-to Canyon
Colo. Outward	5/7-18	22	Home Spring, Fable Valley, Youngs' Canyon, Dark Canyon, Butler Wash, House Park, Beef Basin, Ruin Canyon, Trail Canyon
Colo. Outward Bound School	9/5-17	40	Poison Canyon, Trail Canyon, Young Canyon, Dark Canyon, Butler Wash, House Park, Beef Basin, Ruin Canyon, Sweet Alice, Fable Valley

Table 13. (Continued)

Group	Dates	No. People	Areas Used
Colo. Outward Bound School	9/8-17	24	Beef Basin, Dark Canyon, Poison Canyon, Young's Canyon, Sweet Alice
Nat. Outdoor Leadership School	10/27-11/8	20	House Park, Sweet Alice, Fable Valley, Dark Canyon, Lost Canyon, Fort Knocker Canyon, White Canyon
Nat. Outdoor Leadership School	11/21-27	40	Gypsum Canyon, Fable Valley, Sweet Alice, Beef Basin
	97 DAYS	281 PEOPLE	

Table 14. Number of people and number of days use of BLM lands by wilderness schools, 1978-1982.

Year	Number of People	Number of User days
1978	290	43
1979	162	39
1980	245	87
1981	278	87
1982	281	97

Table 15. Total private and commercial boat trips and passengers through Cataract Canyon (1976-1982). Data from U.S. National Park Service Moab, Utah.

Year	No. Trips	% Increase	No. Passengers	% Increase
1976	279	---	4864	---
1977	300	8	4809	-1
1978	325	8	5575	16
1979	344	6	5728	3
1980	380	10	6115	7
1981	333	-12	5126	-16
1982*	353	6	4949	-3

* 1982 figures based on January-September data.

Table 16. Total private and commercial boat trips and passengers through Cataract Canyon; monthly distribution January-September 1982.

Month	Number of Trips	Number of Passengers
January-March	5	53
April 1-14	3	24
April 15-30	5	56
May	49	631
June	92	1395
July	103	1465
August	72	992
September	25	333

Table 17. Contingency tables for group composition, group size, distance to disturbance and severity of sheep response for hiker disturbance. Numbers in parentheses are expected values.

Group Composition	Severity of Response			
	Little to None	Moderate	Extreme	Totals
Rams-Ewes-Lambs	6 (3.9)	24 (19.85)	15 (21.18)	45
Ewes-Lambs	0 (.88)	3 (4.41)	7 (4.71)	10
Rams	0 (1.15)	3 (5.74)	10 (6.12)	13
Totals	6	30	32	68
$x^2 = 12.41$*				

Group Size

1	0 (.71)	0 (3.53)	8 (3.76)	8
2-7	3 (3.53)	21 (17.65)	16 (18.82)	40
7+	3 (1.76)	9 (8.82)	8 (9.41)	20
Totals	6	30	32	68
$x^2 = 11.22$*				

Distance to Disturbance

0-75 yards	1 (2.20)	13 (11.03)	11 (11.76)	25
75-300 yards	4 (3.08)	14 (15.44)	17 (16.47)	35
300 + yards	1 (.71)	3 (3.53)	4 (3.76)	8
Totals	6	30	32	68
$x^2 = 1.70$				

FIGURES

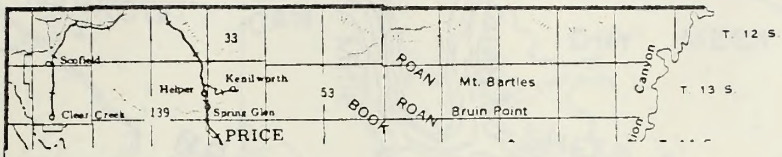
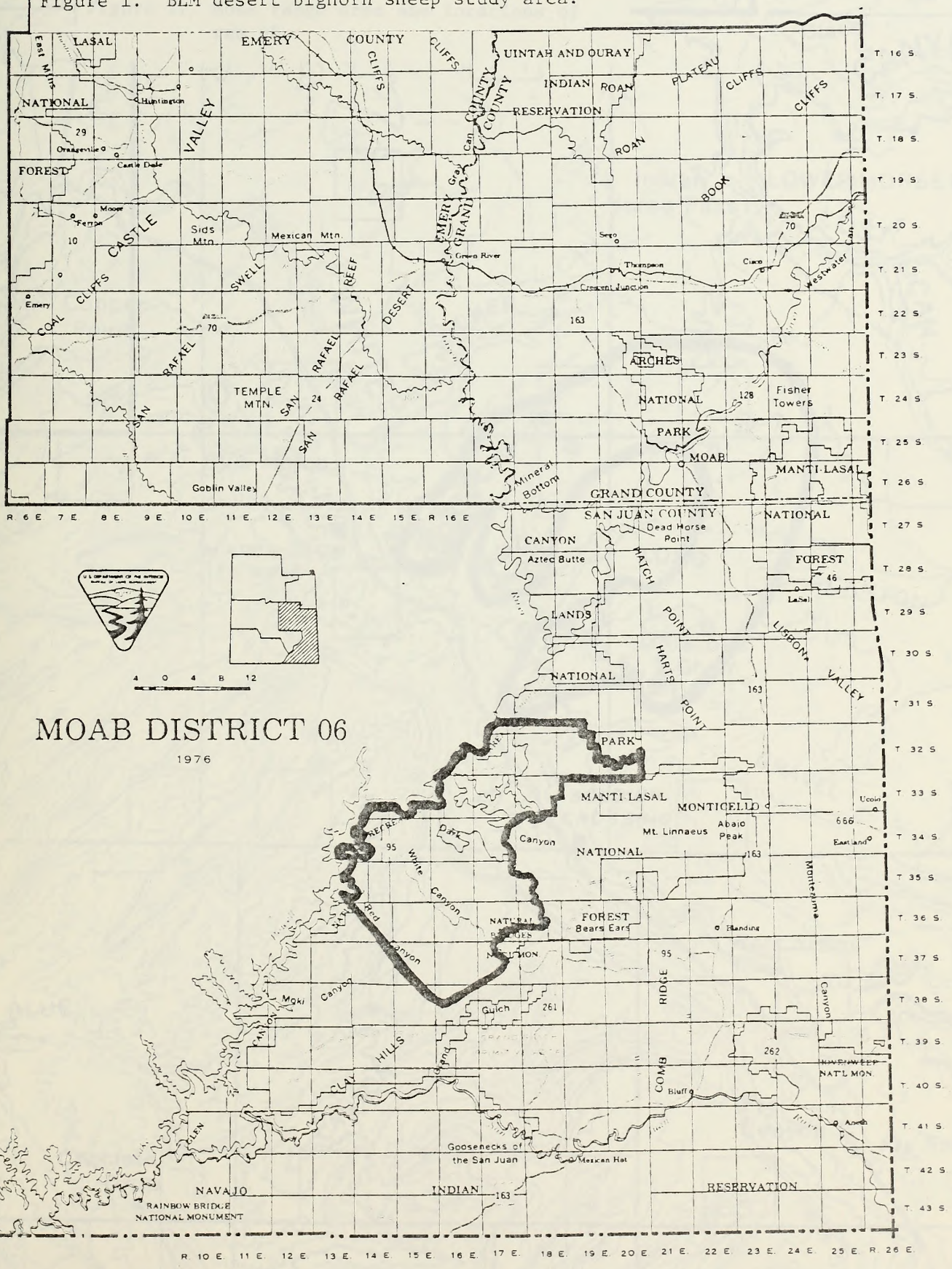


Figure 1. BLM desert bighorn sheep study area.



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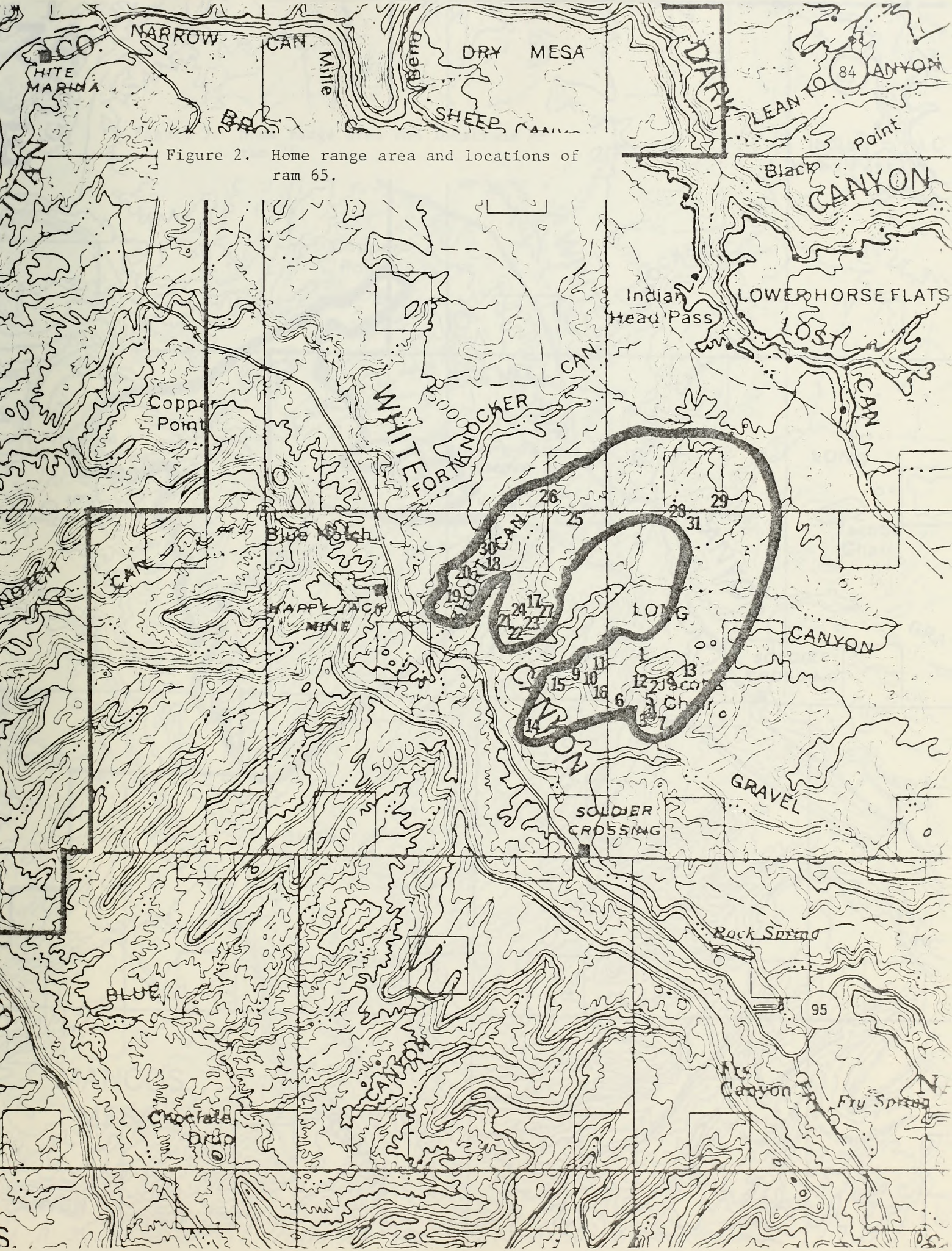


Figure 2. Home range area and locations of ram 65.

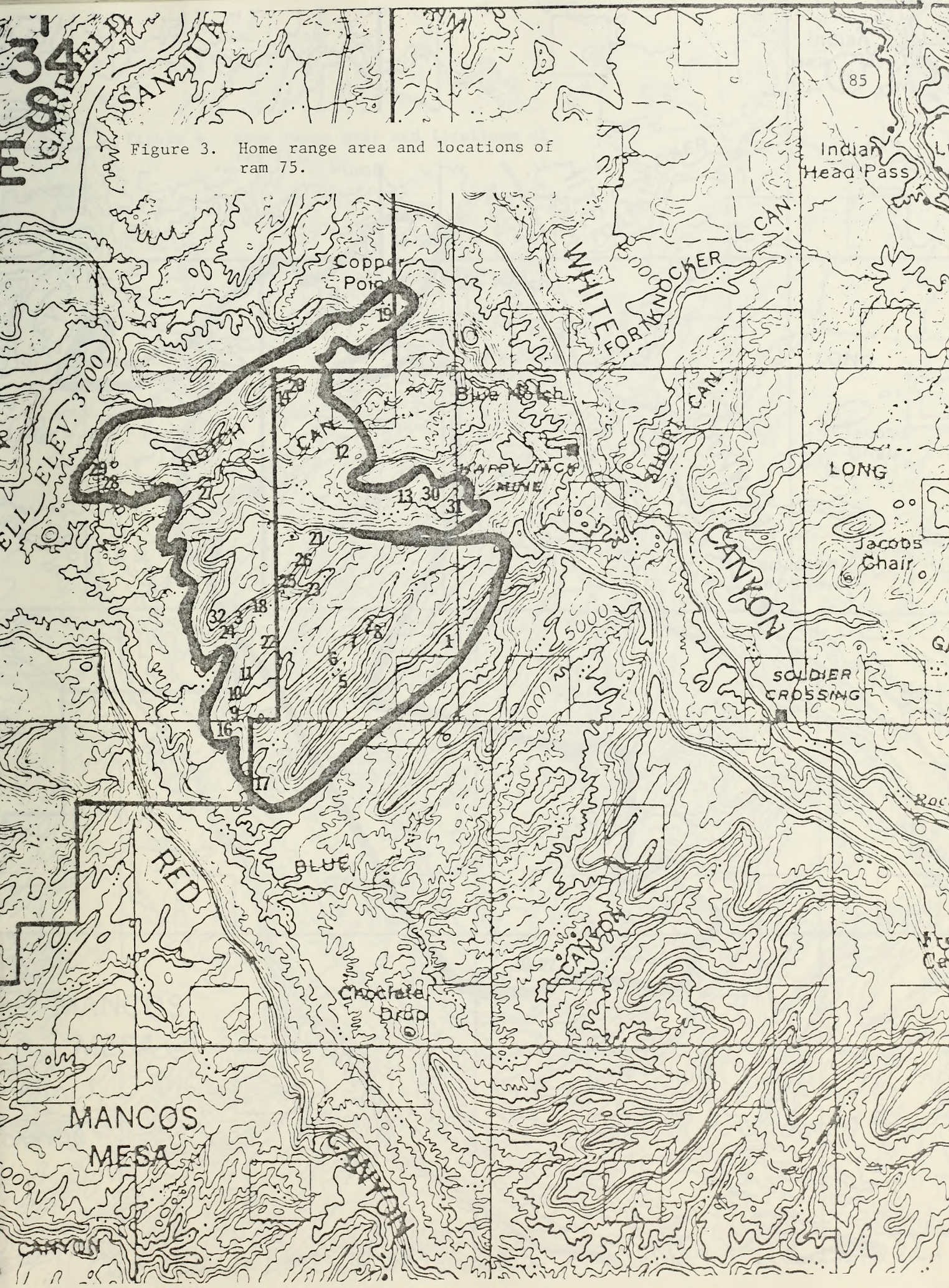


Figure 3. Home range area and locations of ram 75.

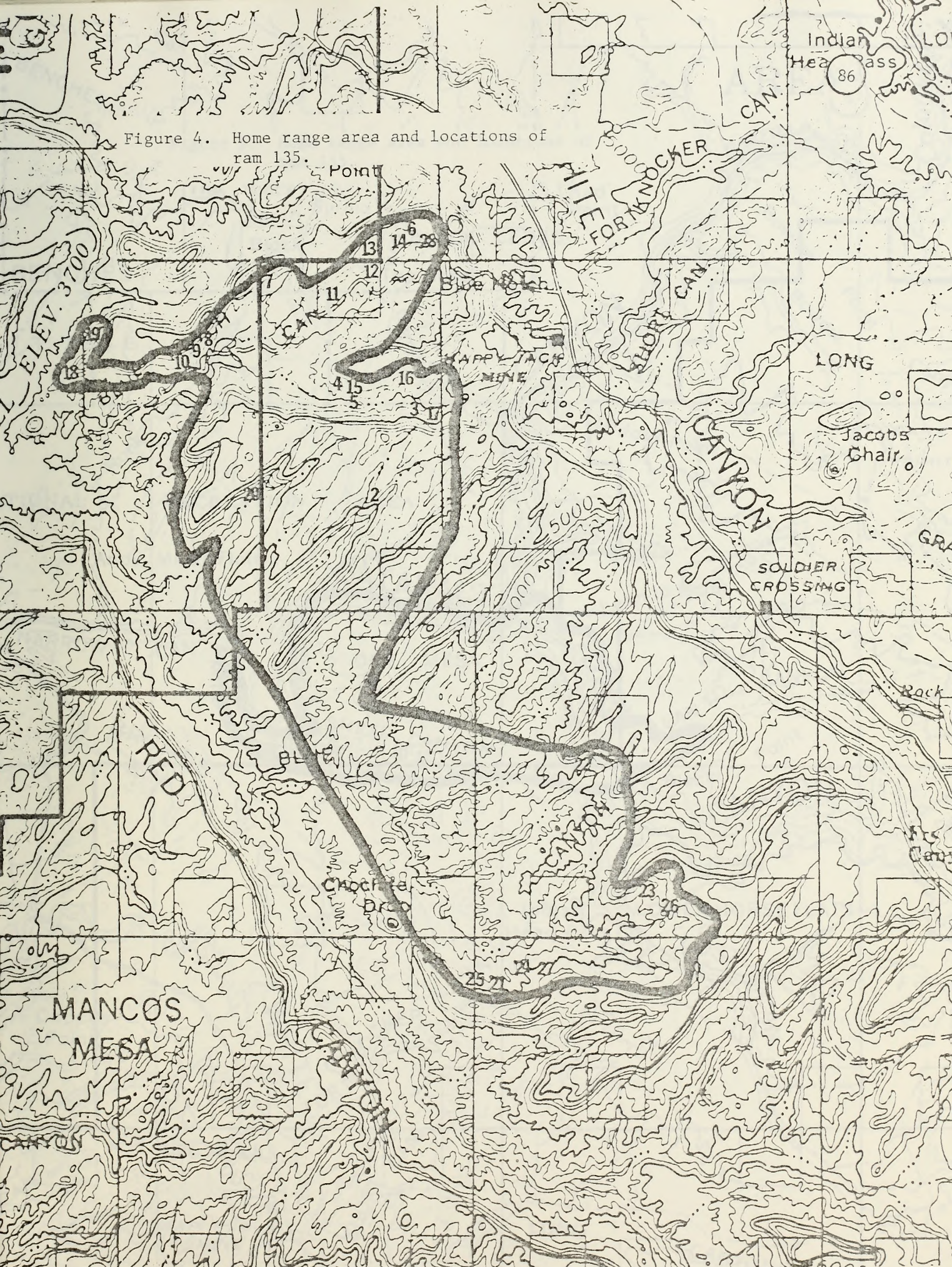


Figure 4. Home range area and locations of ram 135.

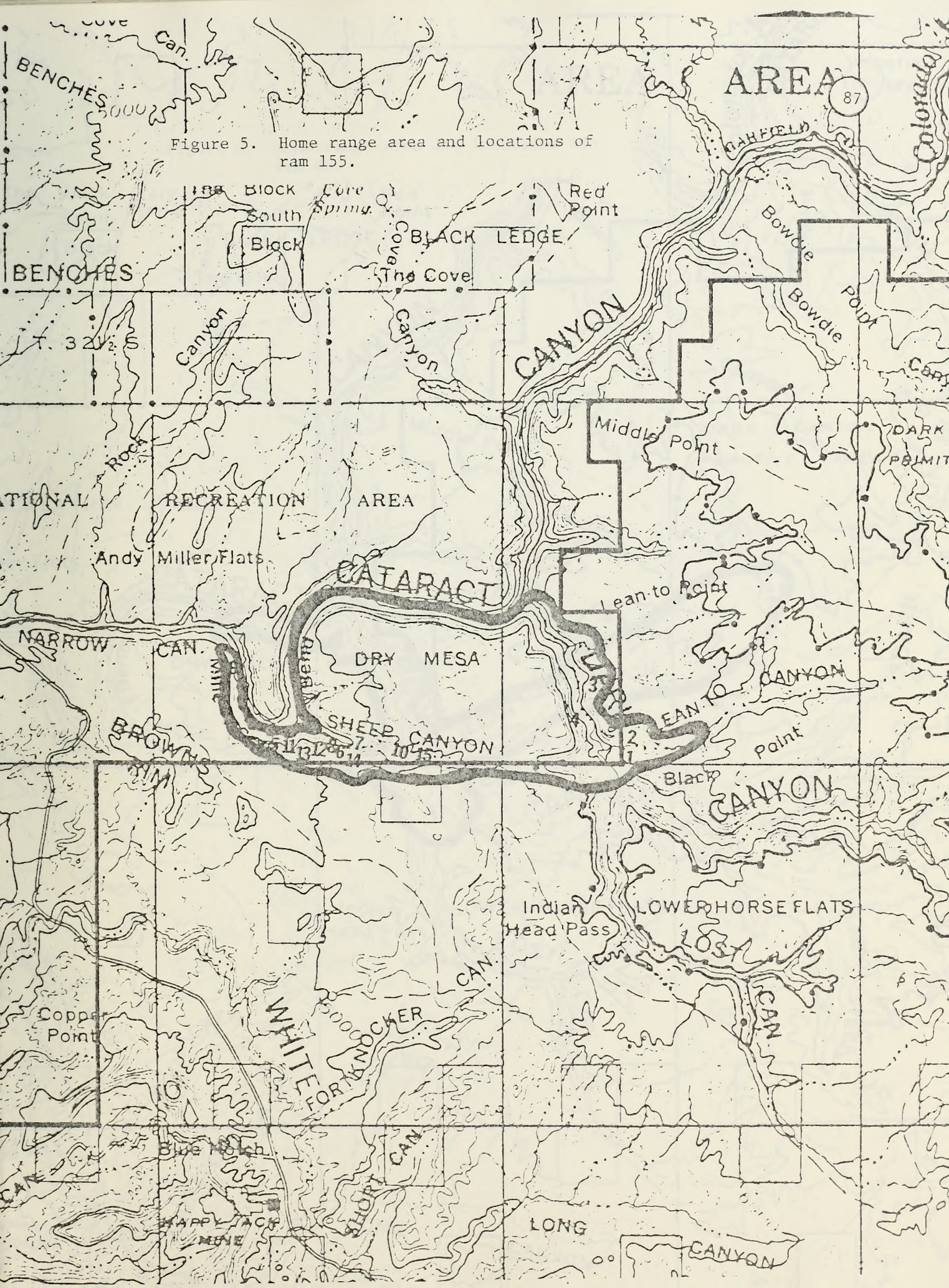


Figure 5. Home range area and locations of ram 155.

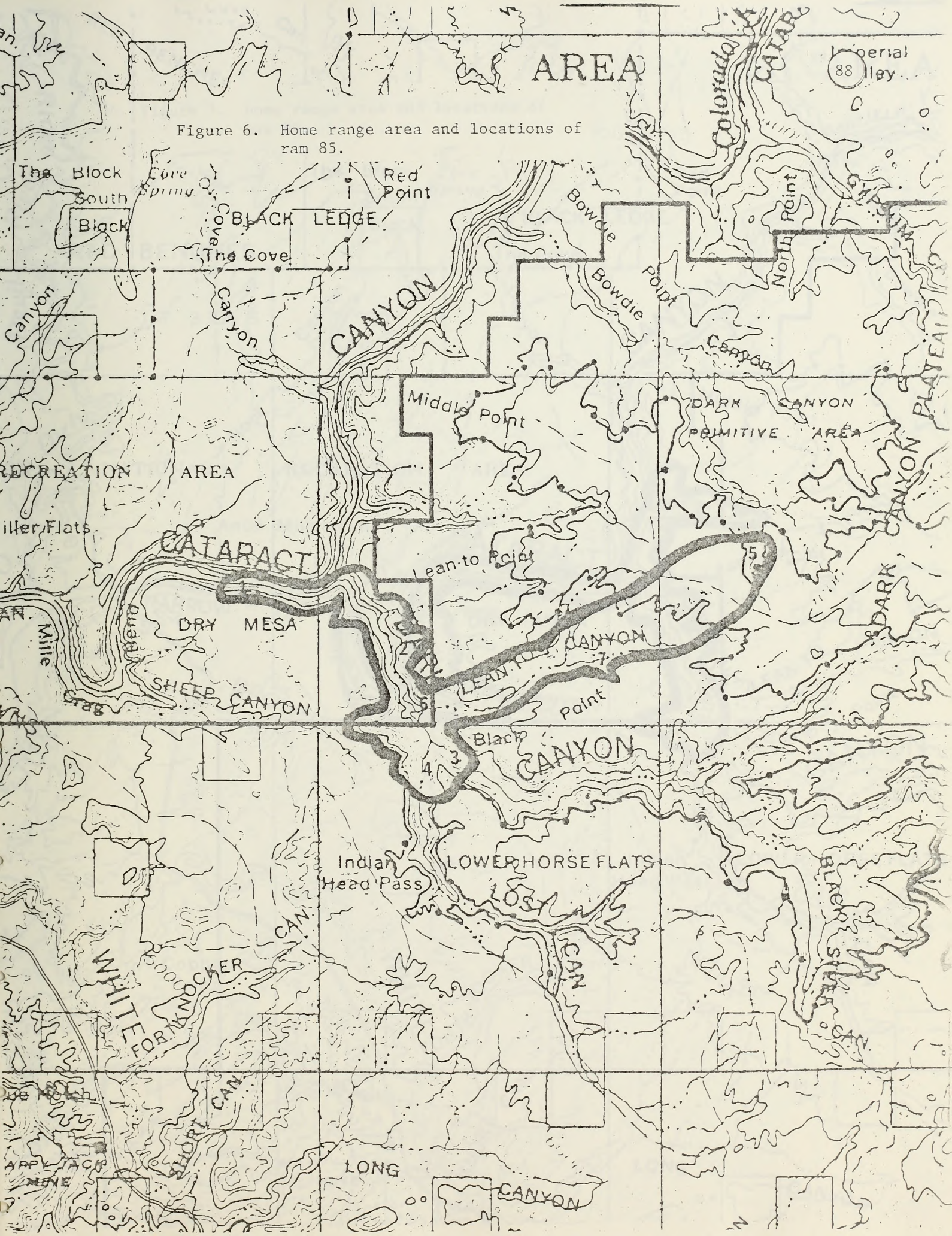


Figure 6. Home range area and locations of ram 85.

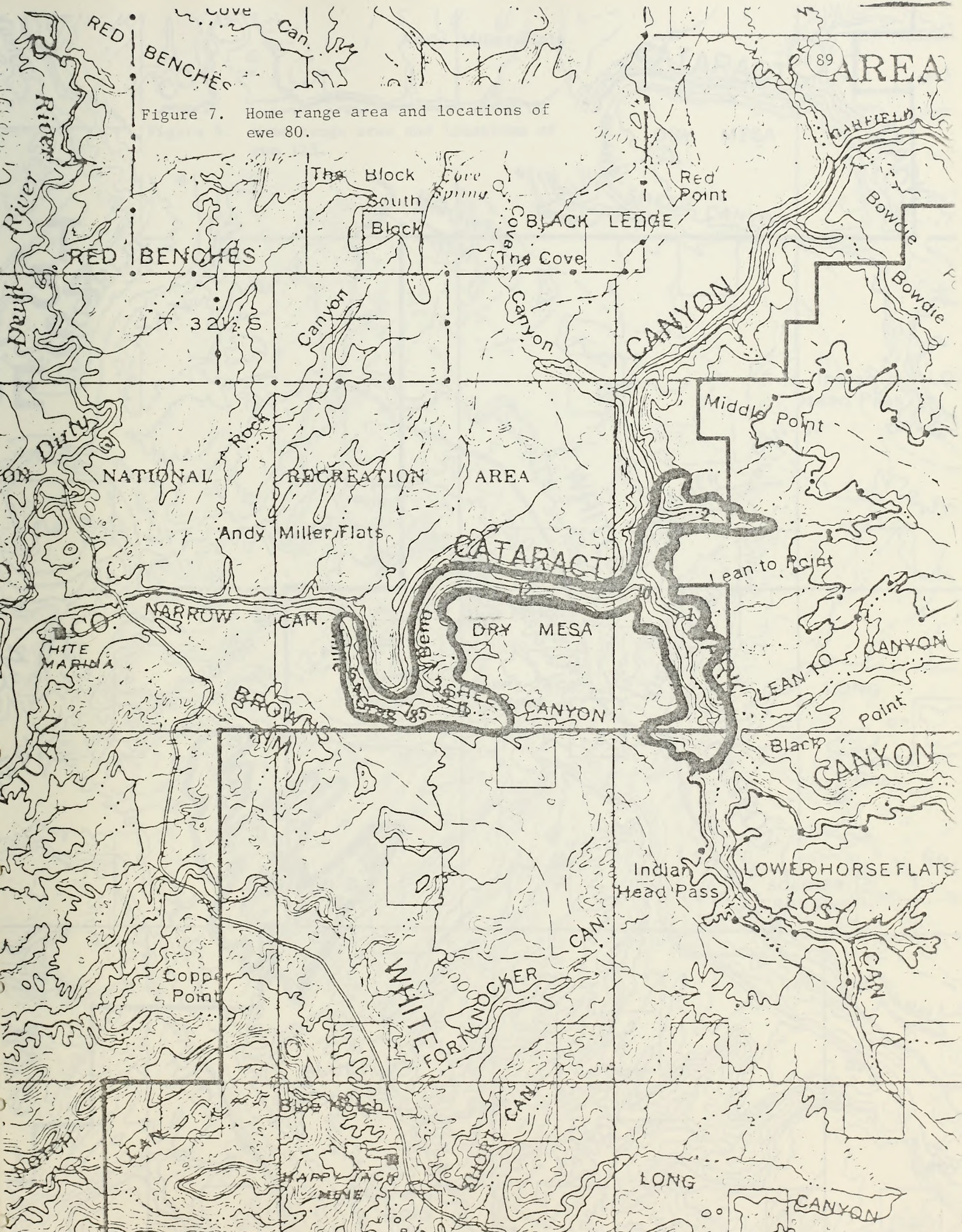


Figure 7. Home range area and locations of ewe 80.

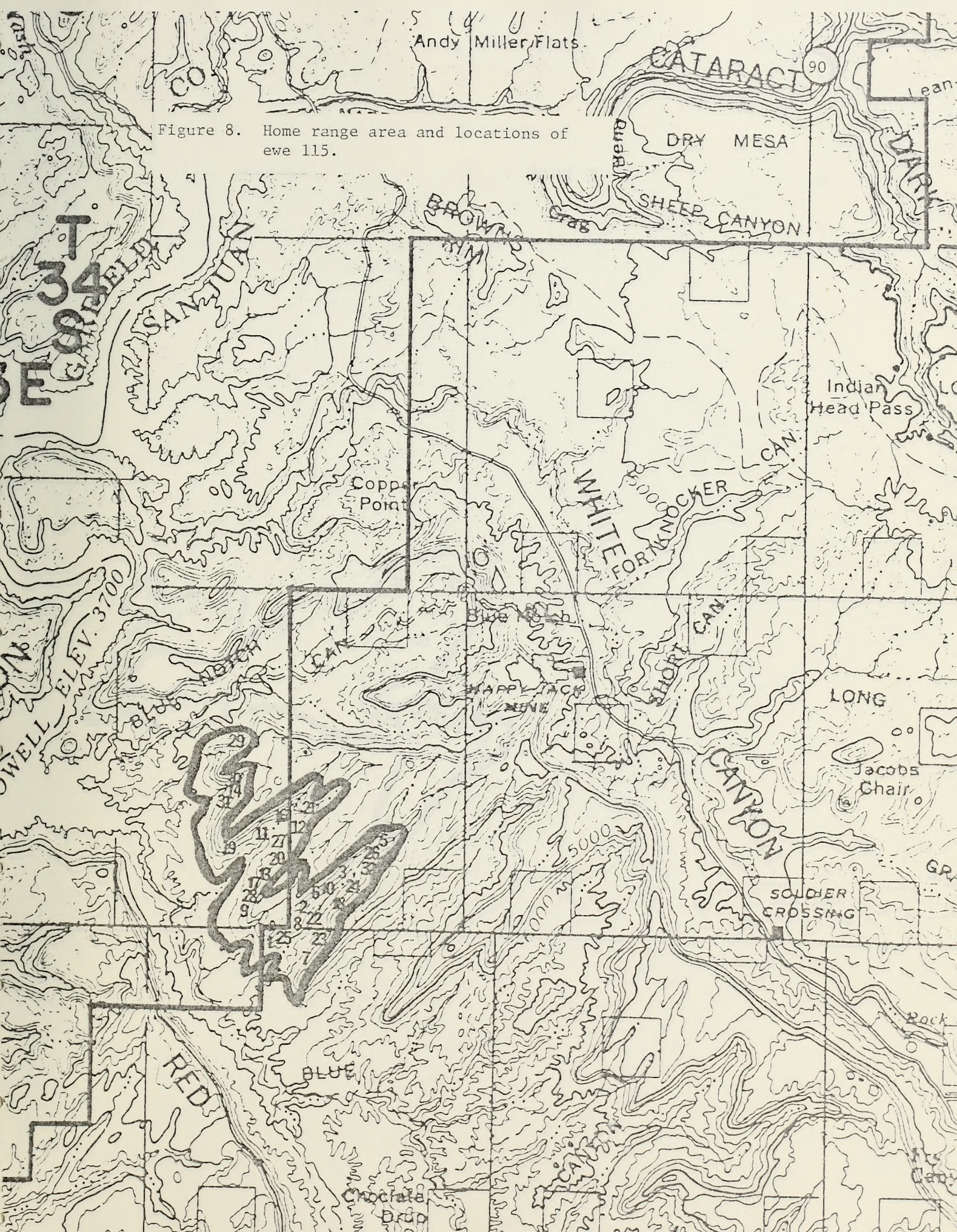


Figure 8. Home range area and locations of ewe 115.

Figure 9. Home range area and locations of ewe 145.

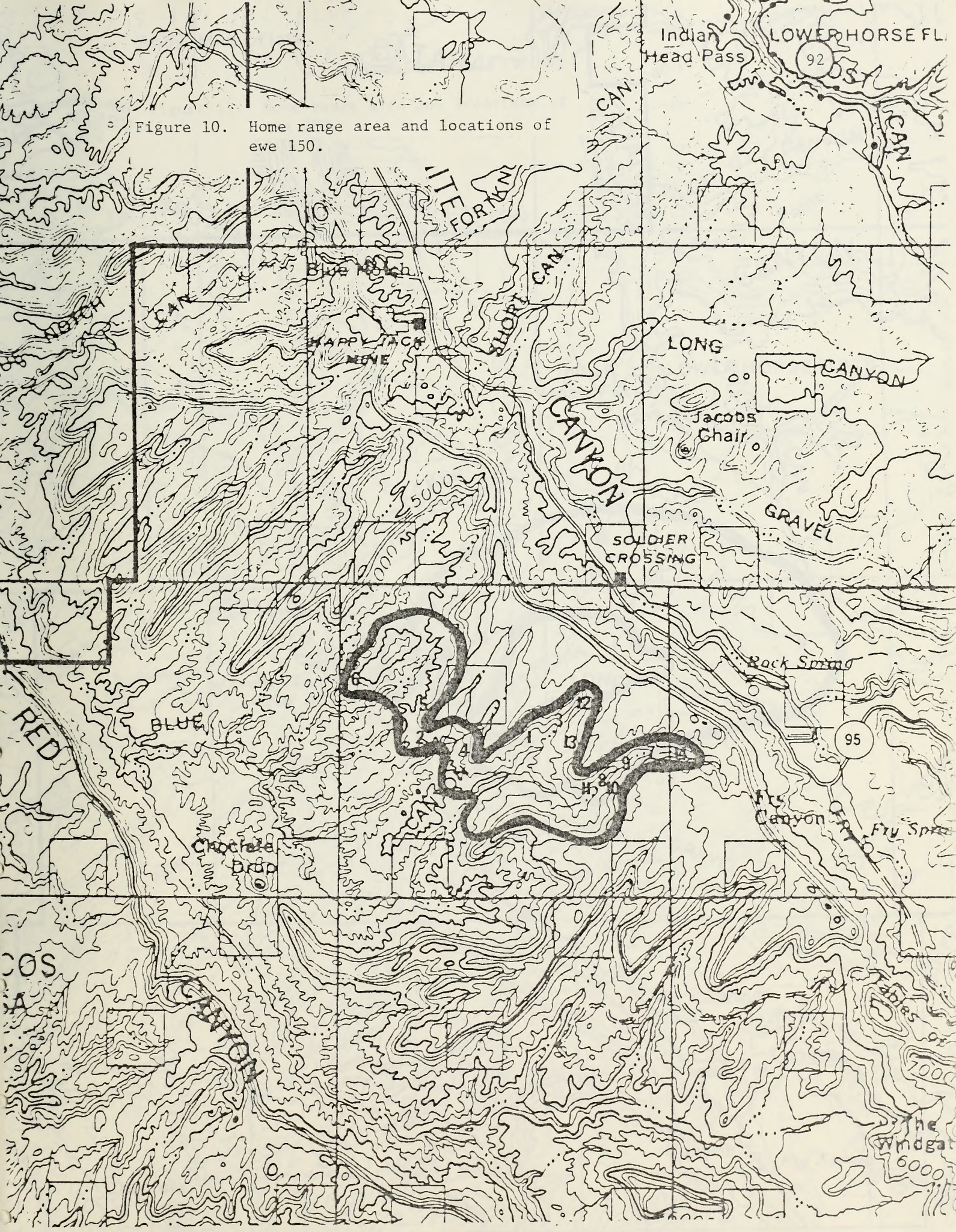


Figure 10. Home range area and locations of ewe 150.

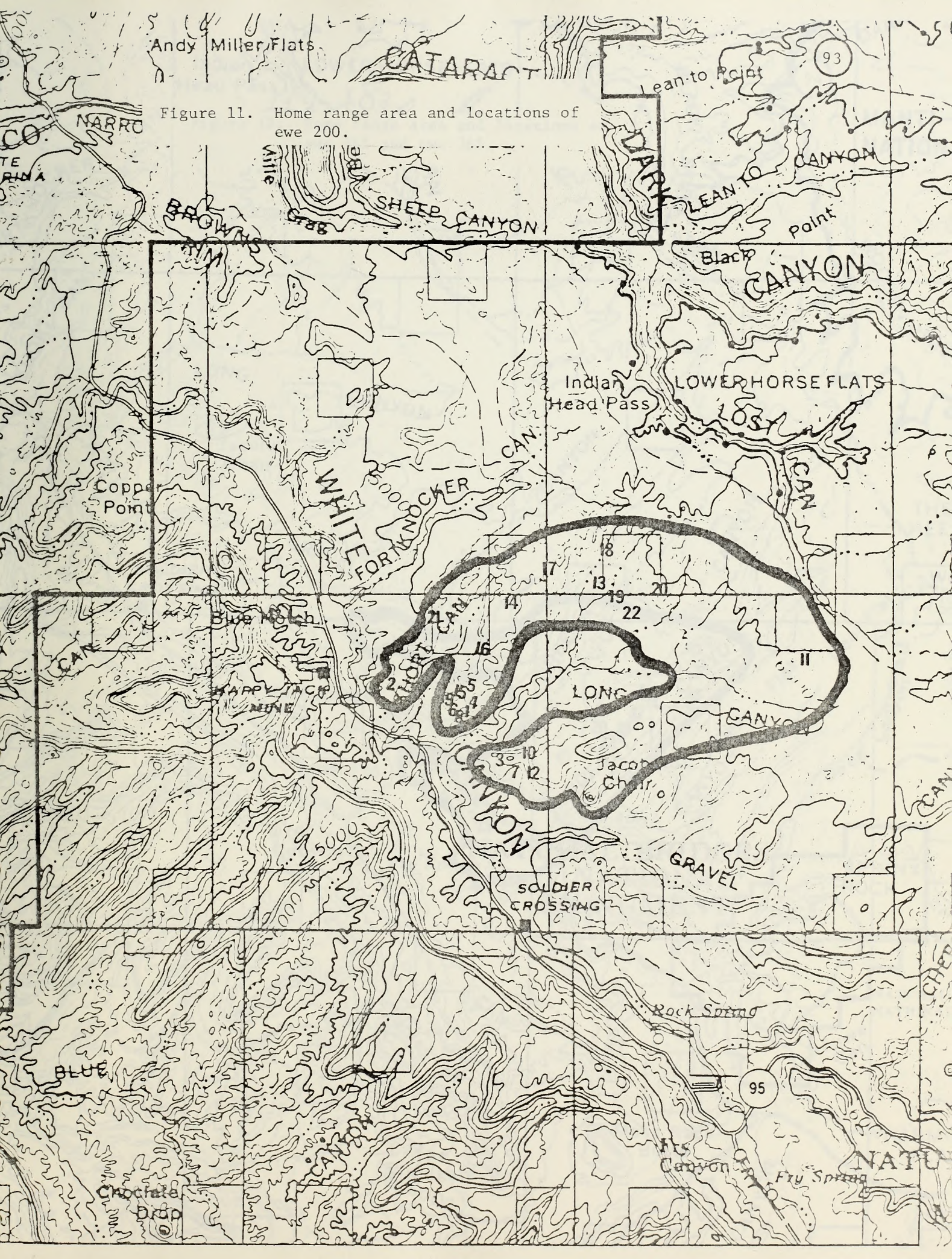


Figure 11. Home range area and locations of ewe 200.

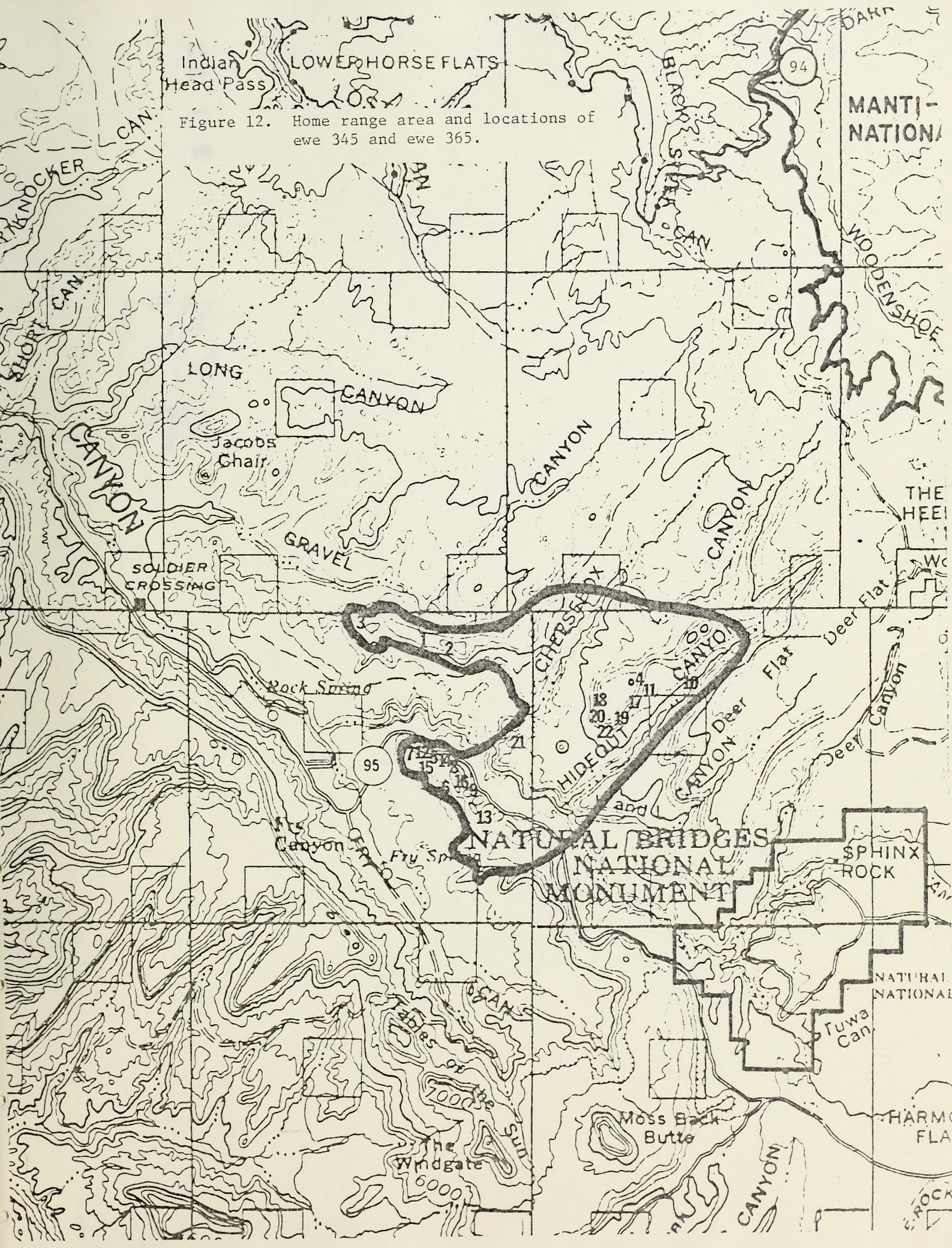


Figure 12. Home range area and locations of ewe 345 and ewe 365.

Figure 13. Locations of desert bighorn sheep and cattle within cattle allotments on BLM land in southeastern Utah.

—xx— Pasture boundries

Allotment boundries

▲ Cattle sightings

● Bighorn sheep sightings

Figure 14. Mining and assessment sites in relationship to lambing and breeding areas in the Red-White Canyon area.

▲ Mining sites

▨ Assessment and exploration sites

○ Lambing areas

□ Breeding areas

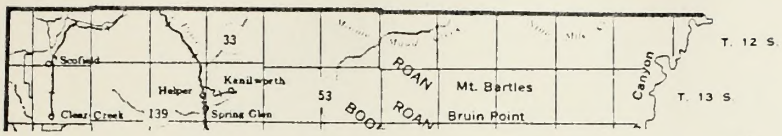
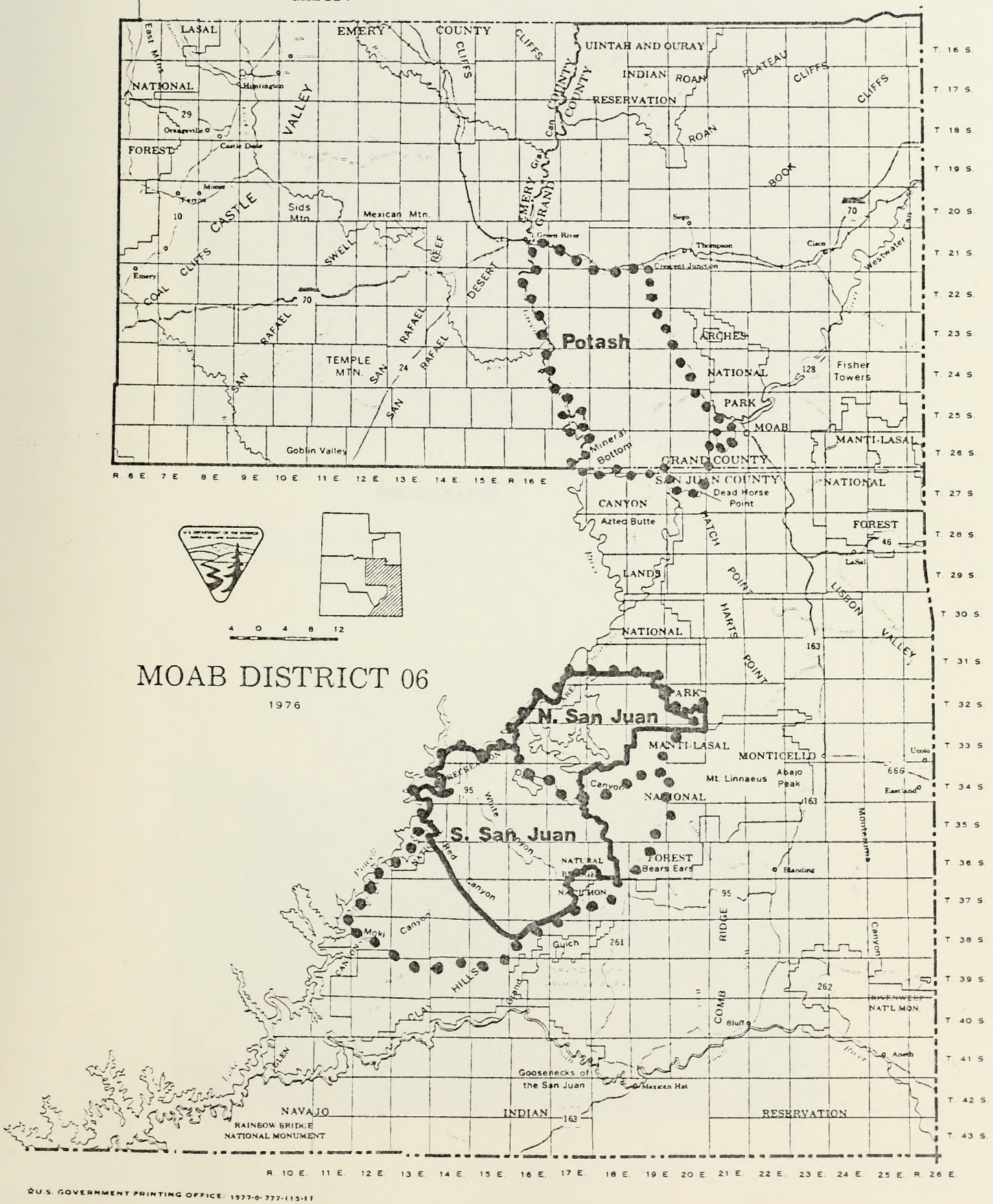


Figure 15. Desert bighorn sheep hunting units.



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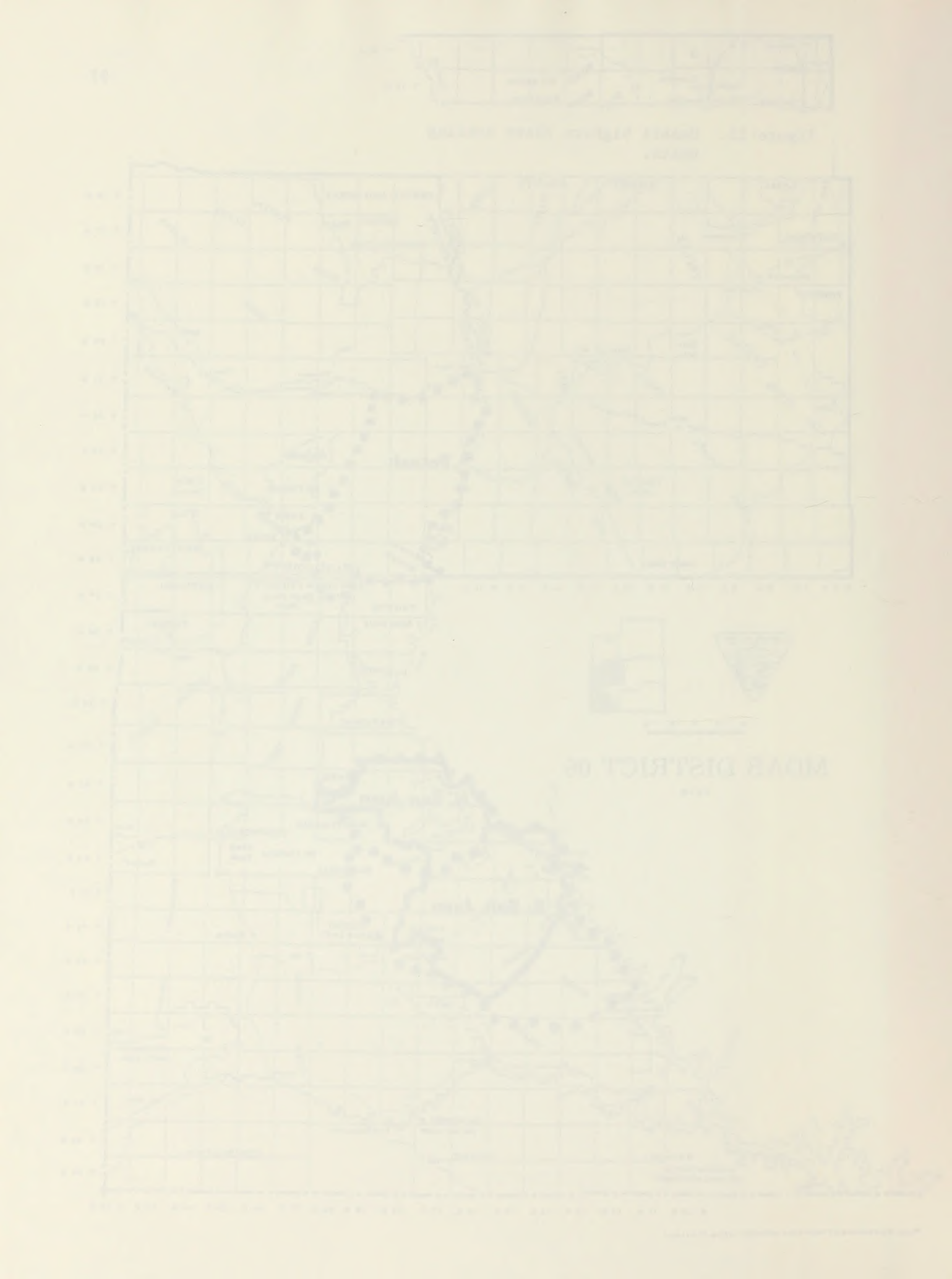
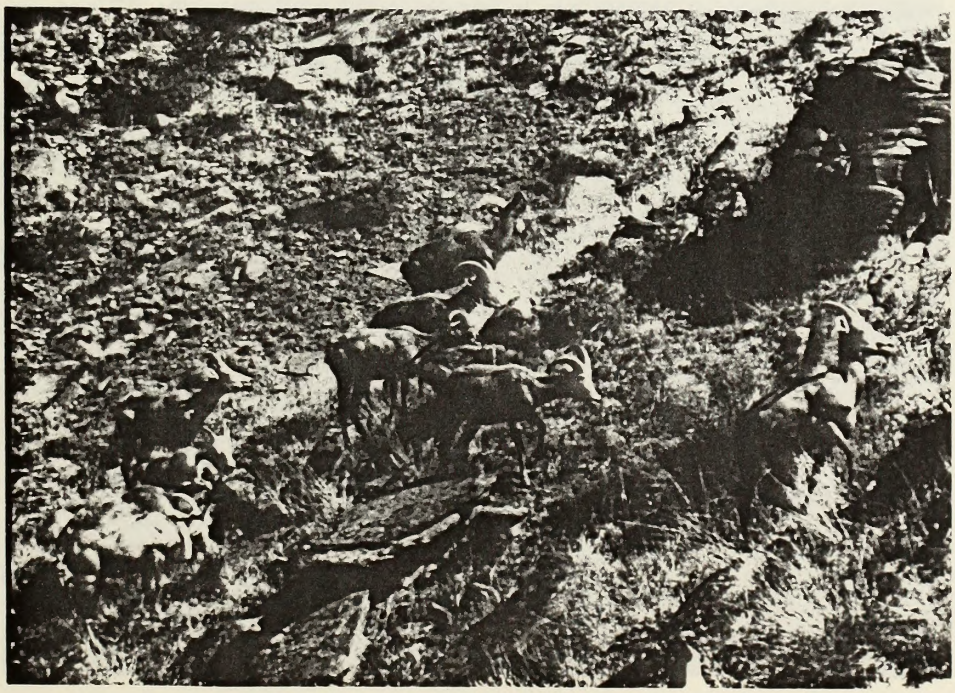


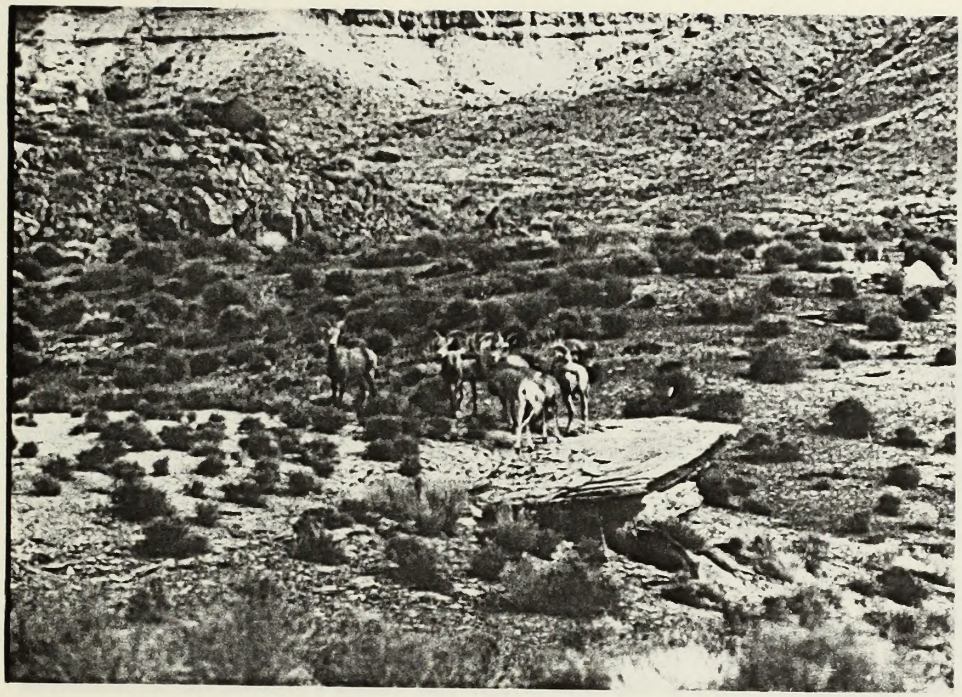
PHOTOGRAPHS

Typical bottom types in Mud Canyon, with dense algae, strong tube slopes, bacterial mat and flat areas.

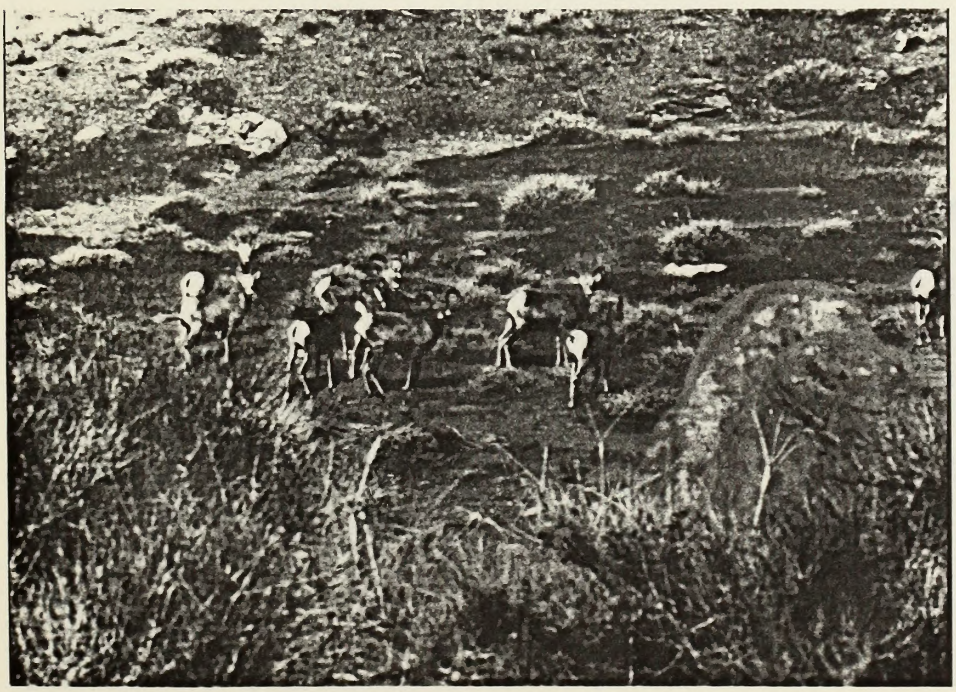
Typical habitat types in Red Canyon; note sheer cliffs, steep talus slopes, benches and flat areas.

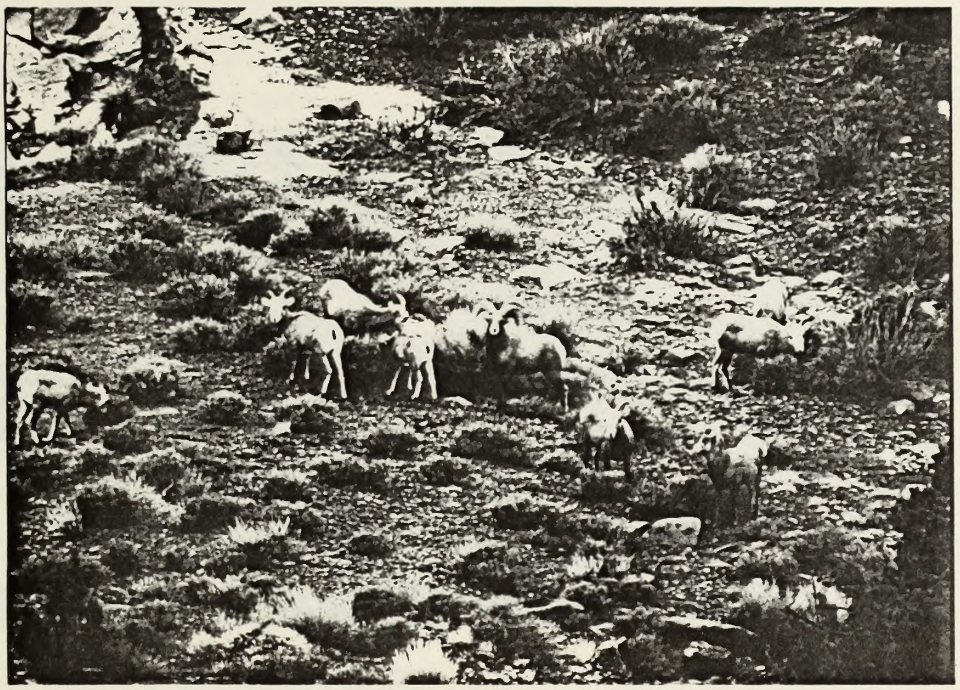
Desert bighorn using Chinle talus slopes and benches in the Red Canyon area.



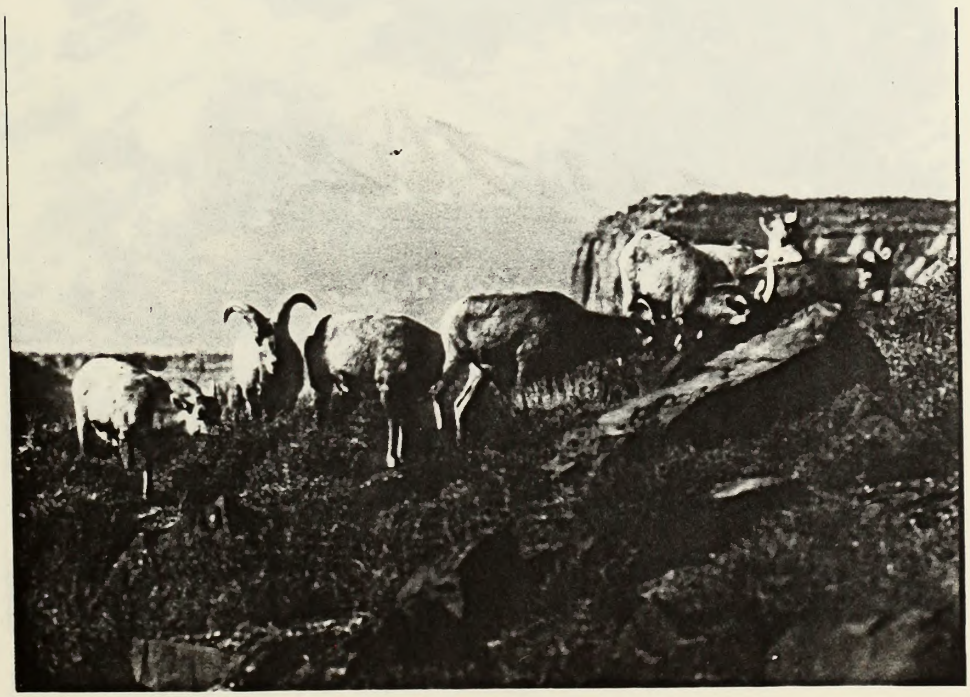


Desert bighorn sheep using blackbrush flats in Red Canyon area.





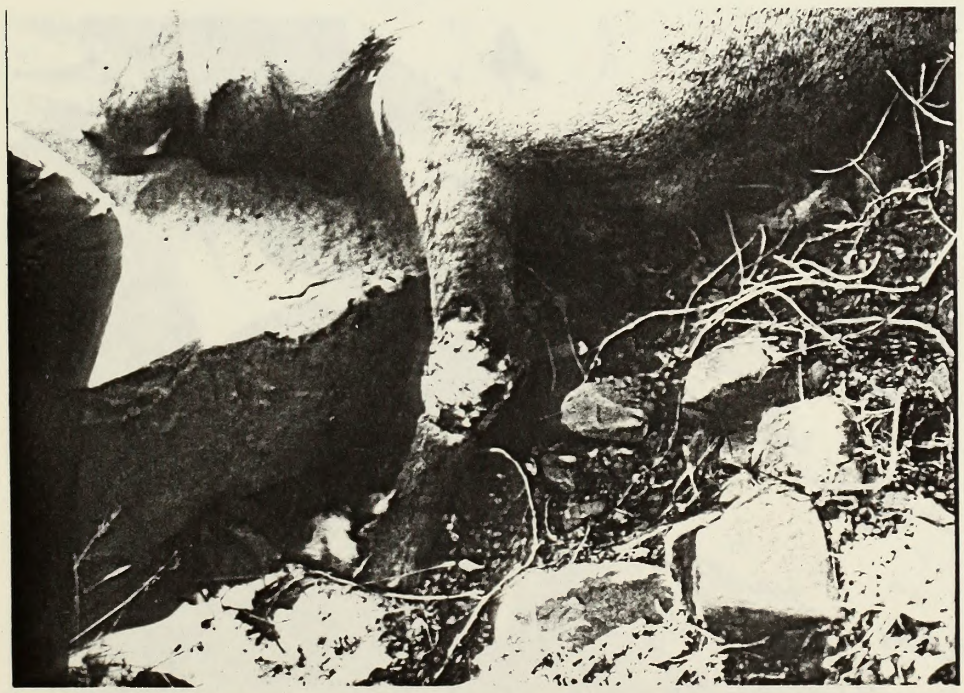
Bighorn sheep commonly use Blackbrush-Galleta Grass flats and benches in the White Canyon area.



Pinyon-Juniper habitat type common in the White Canyon area.

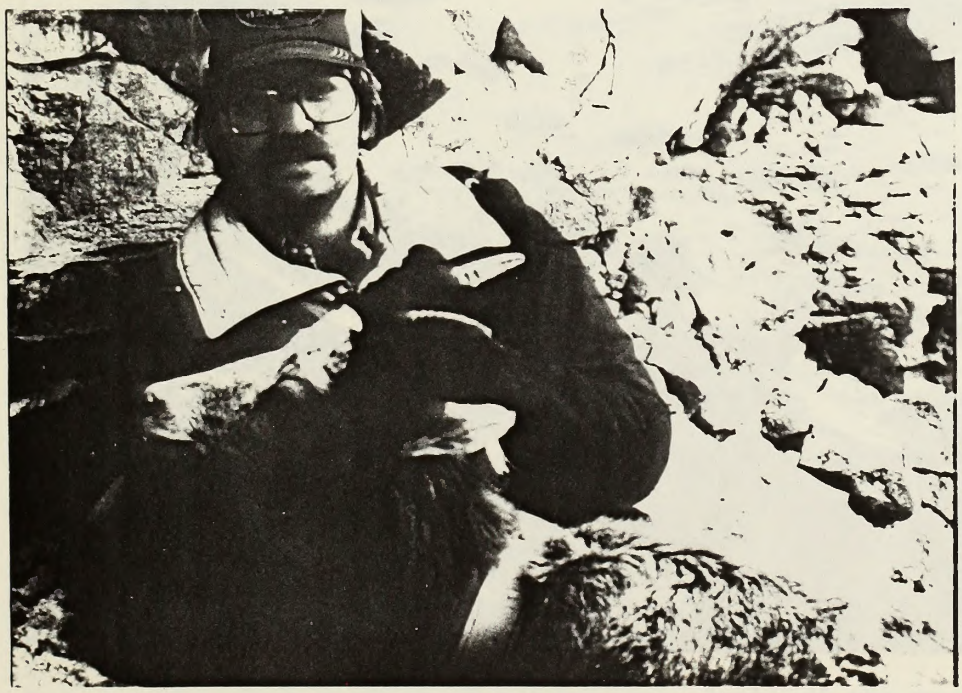
Desert bighorn ewe group in Pinyon-Juniper vegetation near Fry Canyon.

Capture of Ram 316 February 1982, Wilson Canyon.



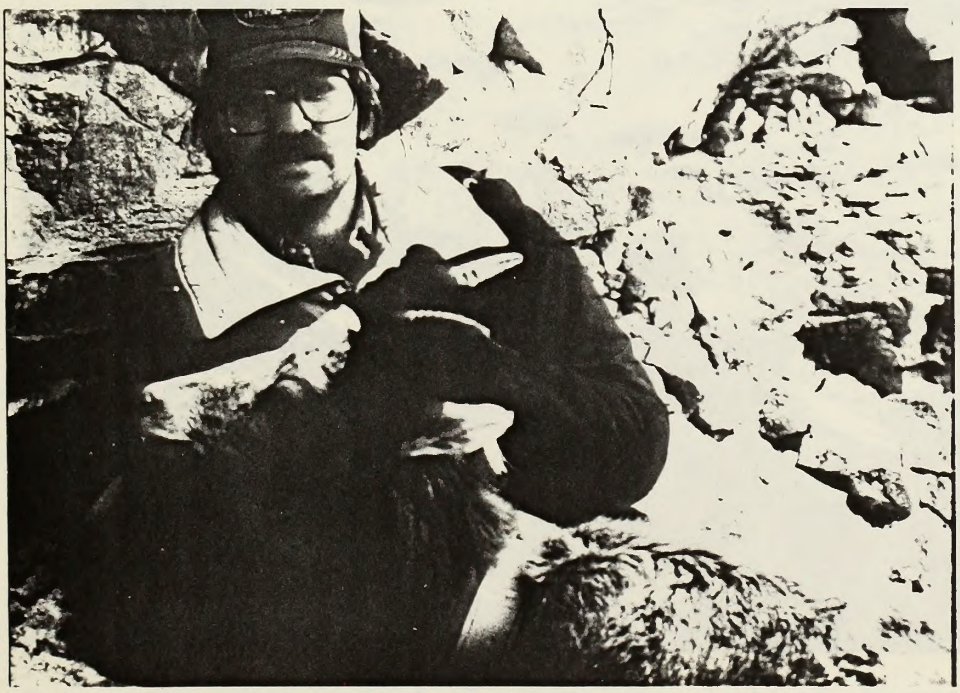
Close up view of Ram 316's broken right foreleg.

Capture site of Ewe 80 in Dark Canyon.



Close up view of Ewe 80 after capture and collaring.

Capture site of Ewe 80 in Dark Canyon.

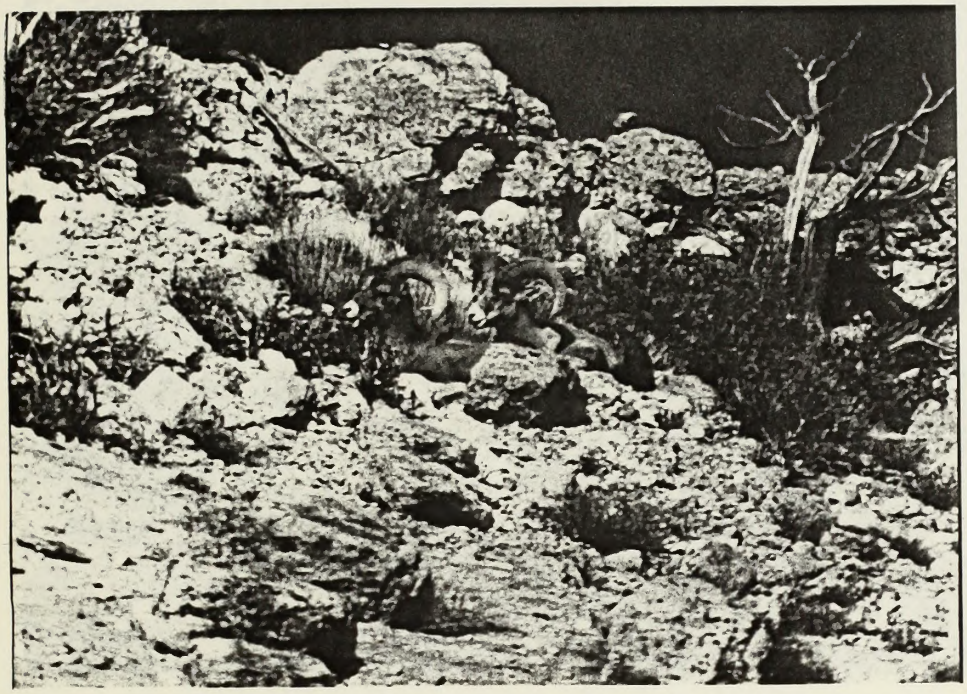


Close up view of Ewe 80 after capture and collaring.

Typical mature ewe to the BLM study area in southeastern Utah.

Ewes groups often consist of mature ewes, lambs of the year and yearlings (male and female offspring from previous year).

Mature rams join ewe groups during the breeding season.

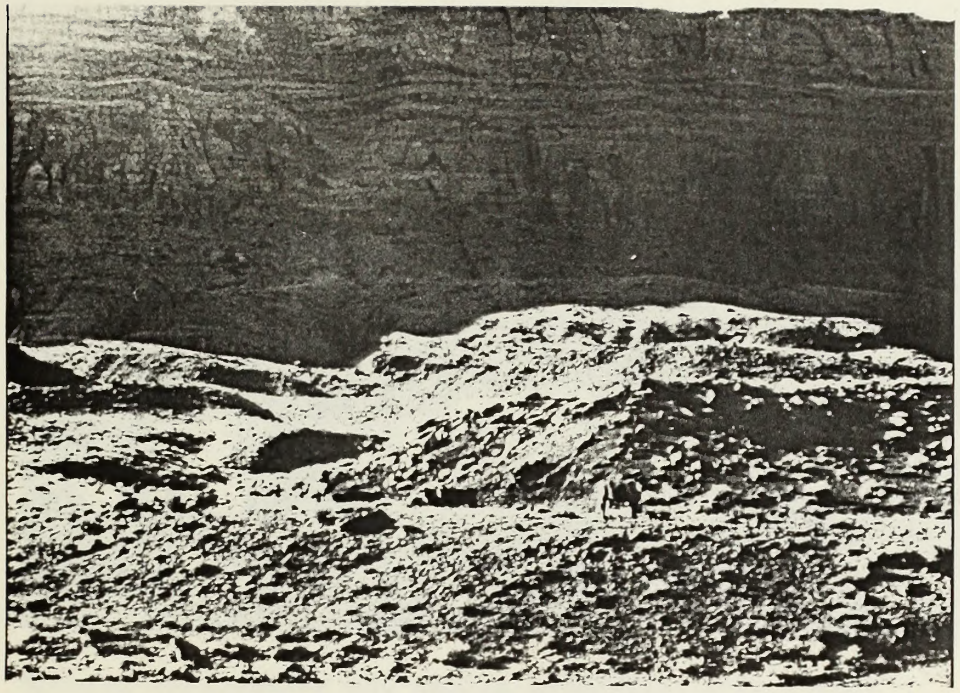


Two mature rams bedded on rocky talus slope; rams usually remain isolated from ewes except during the rut.

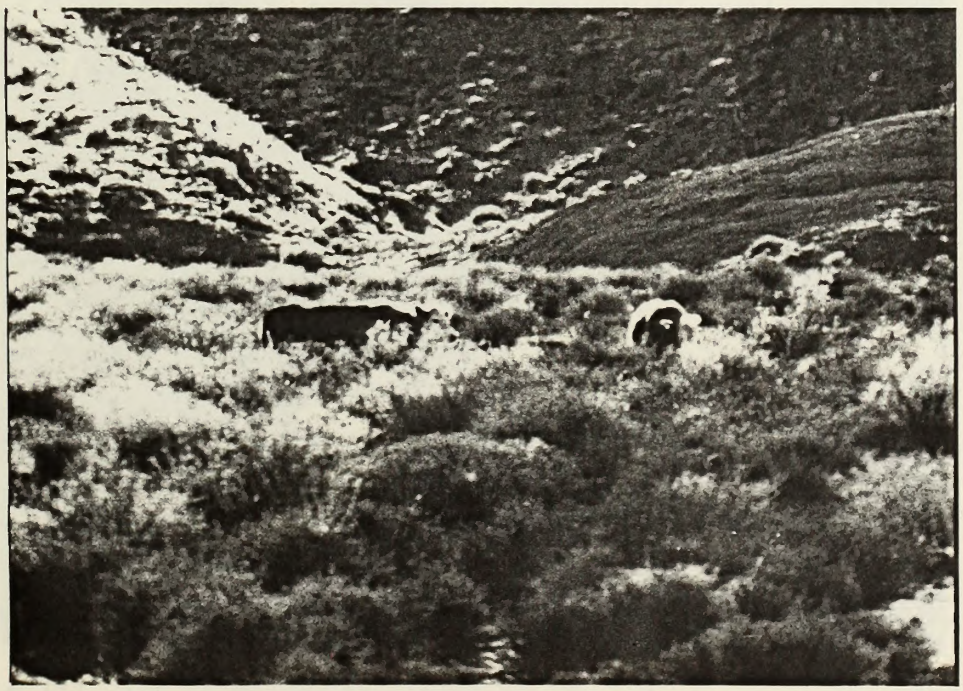
Trophy desert bighorn ram near Jacobs Chair Mesa.

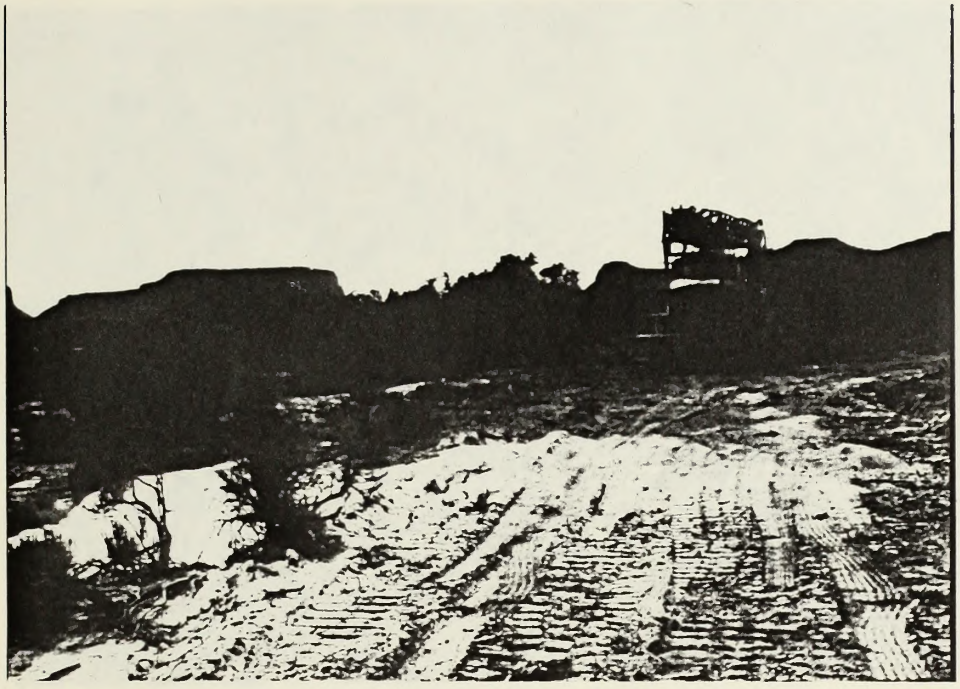
Desert bighorn lamb feeding on Cliffrose bush.

Typical foraging behavior of a group of desert bighorn.

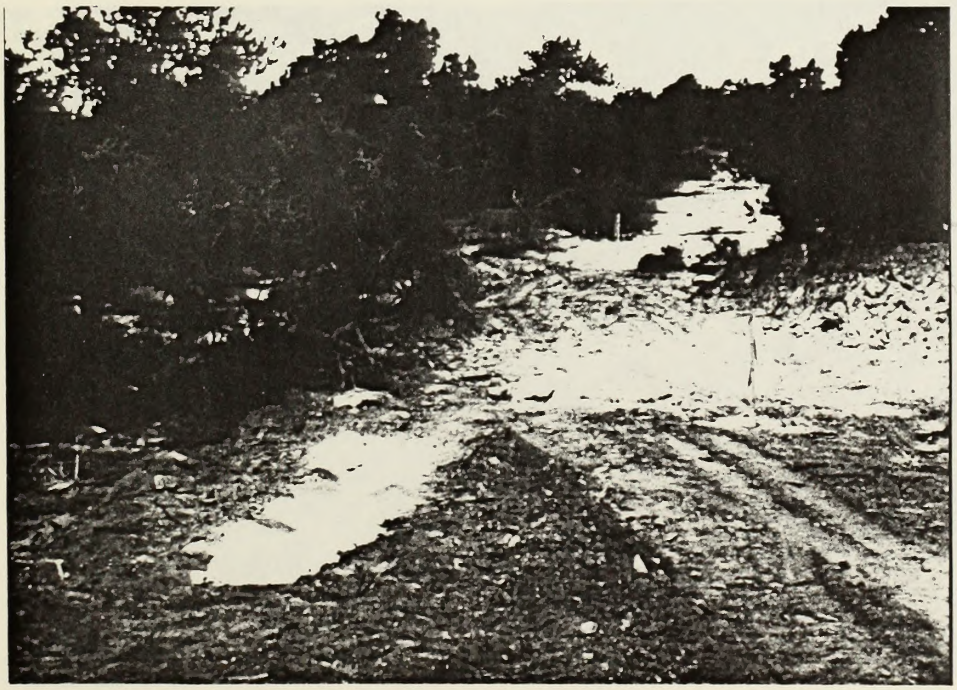


Cattle in desert bighorn habitat in Red Canyon.

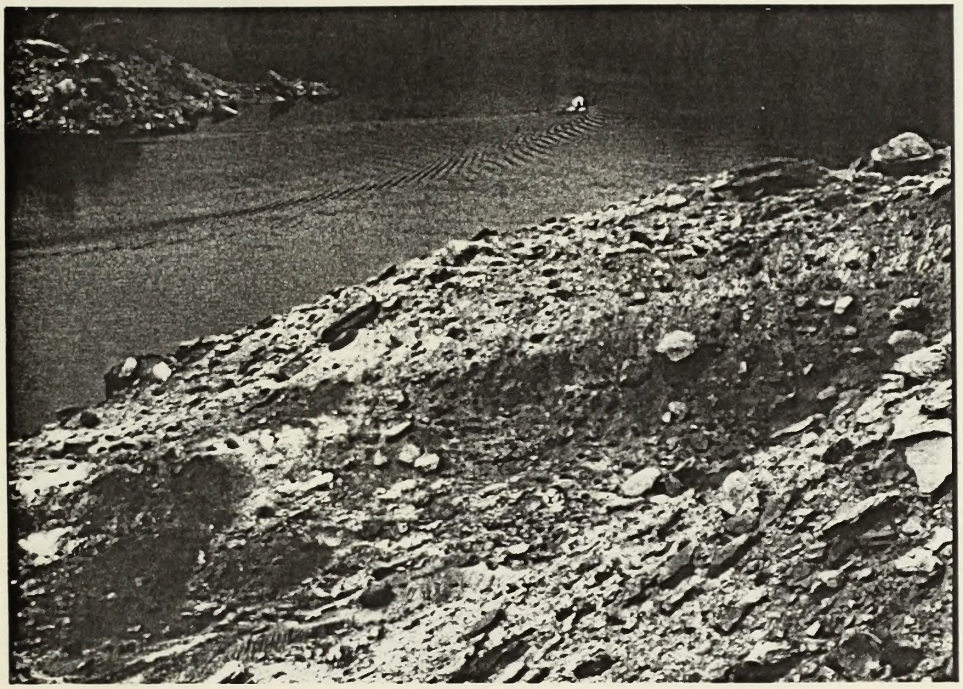




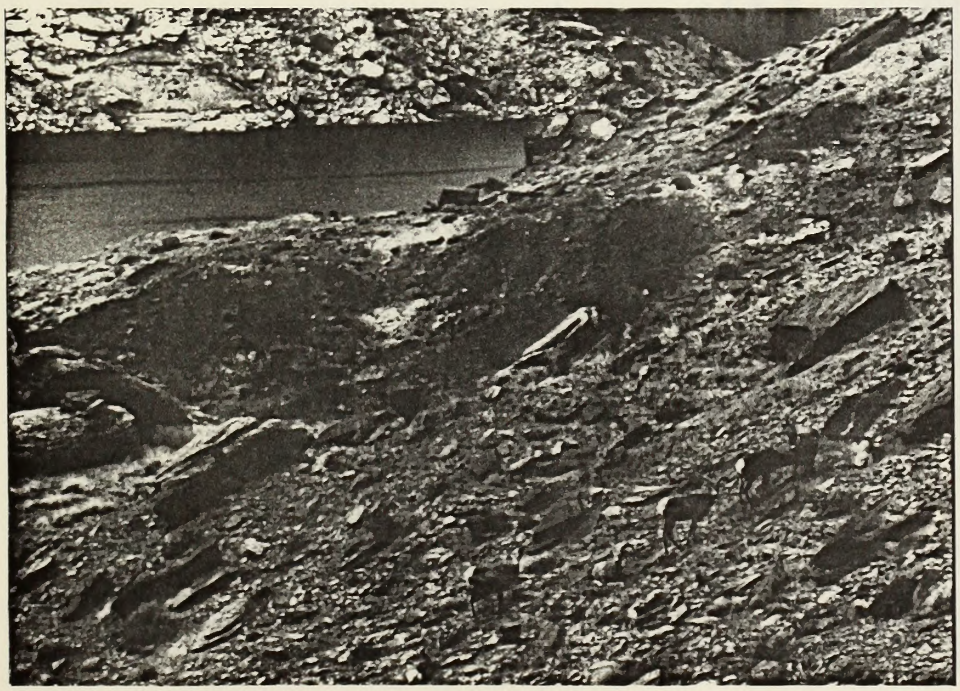
Mineral exploration and mining assessment work occurr periodically in the study area.



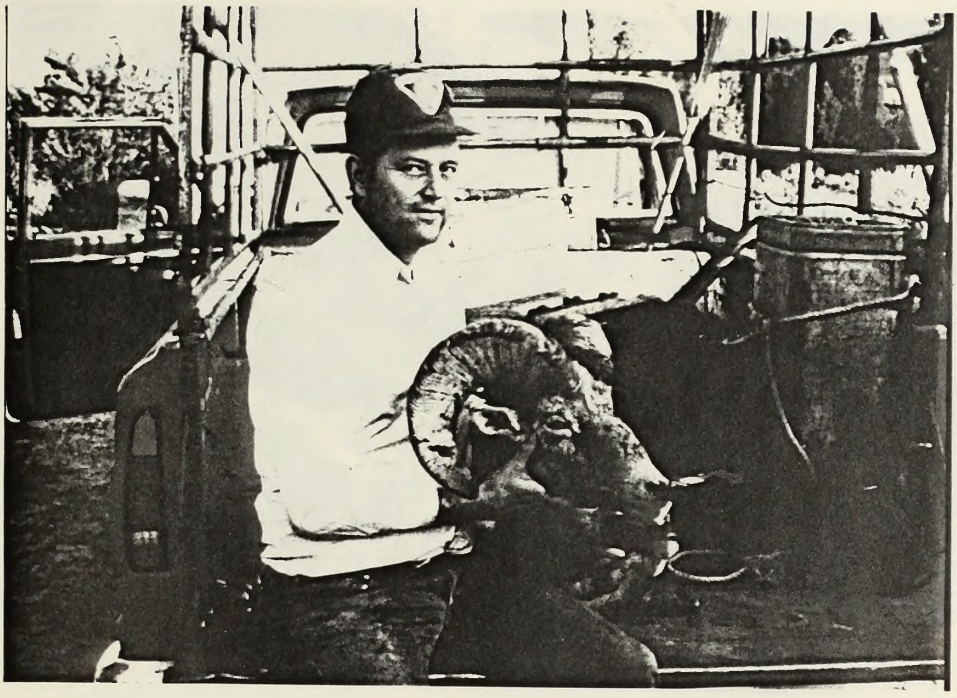
Drill site on Fry Point; drilling done during September 1982 by Minitome Mining Company.



Boaters at Lake Powell often come in close proximity to desert bighorn.



Desert bighorn commonly use steep talus slopes above Lake Powell.



The desert bighorn hunt is a popular recreation activity each within the BLM study area.

Trophy ram harvested during the 1982 desert bighorn sheep hunt in the Red Canyon area.

One harvested ram was infested with ear mites; the sheep was killed in the Red Canyon area.

Several sheep in the Blue Notch Canyon area were infested with an unidentified mouth disease during the fall of 1982.

Close up view of a yearling ram with a moderate case of unknown mouth disease, note blisters on lips.

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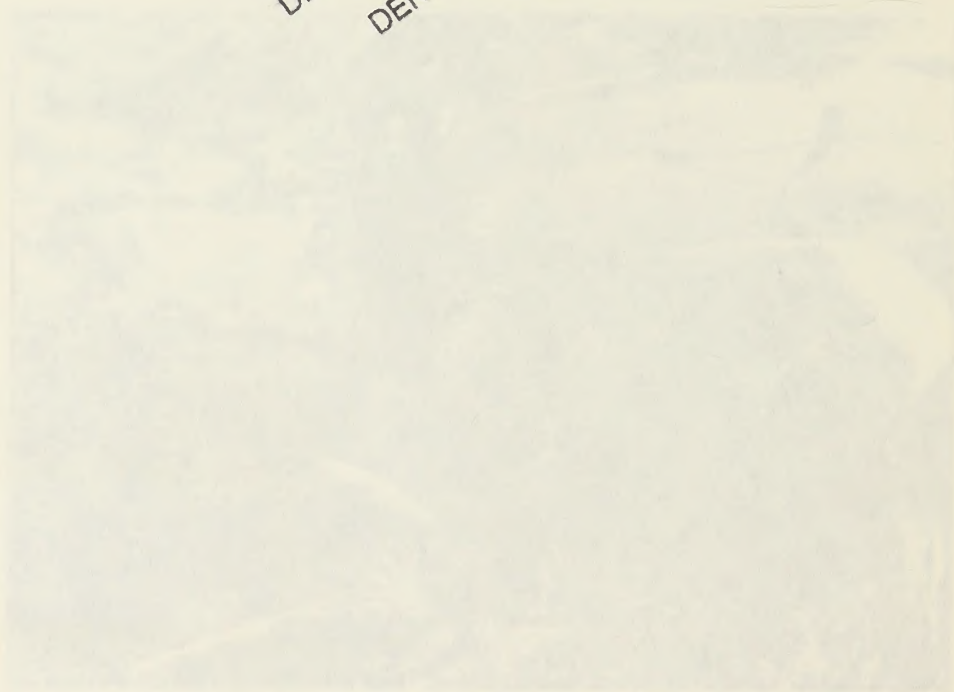

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